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TEACHER EXPERIENCES IN THE USE OF THE ZOOLOGY ZONE MULTIMEDIA RESOURCE IN ELEMENTARY SCIENCE

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Teacher Experiences in the Use of the Zoology Zone Multimedia Resource in Elementary Science** submitted by **Lynne D. Paradis** in partial fulfilment of the requirements for the degree of Doctor of Education.

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In memory of my loving Mother,

Grace E. McNalley,

(November 1, 1925 – May 23, 1998)

Who valued reading and encouraged me to begin my doctoral studies

but could not share in my joys of completion.

ABSTRACT

This interpretive research study explored the experiences of teachers with the use of the Zoology Zone multimedia resource in teaching grade three science. Four generalist teachers used the multimedia resource in the teaching of the Animal Life Cycle topic from the Alberta grade three science program. The experiences of the teachers were examined through individual interviews, classroom visits and group interviews. Three dimensions of the study, as they related to elementary science teaching using the Zoology Zone multimedia resource were examined: (a) technology as a teaching resource, (b) science education and constructivist theory, and (c) teacher learning.

In the area of planning for instruction, the teachers found that using the multimedia resource demanded more time and effort than using non-computer resources because of the dependence teachers had on others for ensuring access to computer labs and setting up the multimedia resource to run on school computers.

The teachers felt there was value in giving students the opportunity to independently explore the multimedia resource because it captured their attention, included appropriate content, and was designed so that students could navigate through the learning activities easily and make choices about how to proceed with their own learning. Despite the opportunities for student directed learning, the teachers found that it was also necessary to include some teacher directed learning to ensure that students were learning the mandated curriculum.

As the study progressed, it became evident that the teachers valued the social dimensions of learning by making it a priority to include lessons that encouraged student to student interaction, student to teacher interaction, small group and whole class discussion, and peer teaching. When students were engaged with the multimedia resource, the teacher facilitated learning by circulating to each student and discussing student findings.

Teachers focussed primarily on the content components of the Alberta science program of studies. They stated that the time allotted for science instruction was insufficient to effectively address the teaching of skills for science inquiry and of the 'big' ideas in science. The teachers stated that they valued inquiry teaching, constructivist teaching and the integration of the Information and Communication Technology (ICT) outcomes but that utilizing these teaching approaches was challenging because of the depth and breadth of the mandated curriculum. It became apparent that science instruction did not meet all the expectations of the mandated science curriculum and that the teachers did not plan for the integration of the ICT outcomes.

The teachers in the study stated that they felt that multimedia resources did have a place in the elementary science curriculum and that the ICT outcomes could be achieved as part of science instruction using the Zoology Zone multimedia resource. The study concludes with some implications for teachers, educational policy makers and school administration, related to the use of multimedia resources in the teaching of elementary science and in the teaching of the ICT outcomes.

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CHAPTER ONE
INTRODUCTION

Overview of Study

This study explored the experiences of four Alberta teachers with the use of the Zoology Zone multimedia resource in their classrooms. The connections between the classroom teacher's responsibility as science teacher and technology educator were examined in this research project in which elementary generalist teachers used the Zoology Zone multimedia resource in the teaching of the Animal Life Cycle topic from the Alberta grade three science program.

Computer Technology in Education

> As technology begins to transform classrooms and learning environments in many countries, we must continue to discuss the principles on which they are based toward dual objectives: revising the accumulated knowledge gained from research, and making informed improvements to education. (Vosniadou, DeCorte, Glaser, & Mandl, 1996, p. 8)

We are in a time of escalating technology use in education in Alberta. Technology is not likely a passing fad or trend. Unlike some other mandates from the provincial department of education that have been introduced and then abandoned (e.g., program continuity in the mid eighties), mandates for technology integration appear firm.

The premier of the province announced to the Alberta electorate that by 1998 all Alberta schools would be linked to the Internet and that all students would be provided opportunities to learn technology as part of the regular school program. To this end, Alberta Education, now named Alberta Learning, published the Information and Communication Technology (interim) document, which identified minimum technology competencies for Alberta students. It provided guidelines on what students should learn about the nature of technology, about how to use and apply a variety of technologies, and about the impact of technology on individuals and society. This draft document was subsequently revised and released by Alberta Learning in the spring of 2000 with a provincial directive for implementation beginning the fall of 2000. These promises and

expectations have had significant impact on Alberta schools as educators proceeded to address the new mandate for computer technology integration in the teaching of all programs of study.

Tremendous resources have been directed to financing technology systems in schools and in providing training for professional staff in the utilization of computer technology. Schools no longer have a choice to integrate technology in the elementary school program.

In elementary classrooms there are three common applications of technology: (a) computer assisted instruction (CAI), (b) information and communication technology (ICT), and (c) technology as a cognitive tool. These three applications of computer technology are explained further in the Literature Review in Chapter Two.

A challenge exists for elementary school teachers to develop instructional programs that address both the learning outcomes for the subjects they teach as well as the technology outcomes that they are expected to integrate in all subjects. In Alberta, most grade three teachers are generalists. As generalists, they have the responsibility to teach most of the subjects in the grade three program. Given the mandates in the individual programs of study and the training and experience of the teacher, teaching approaches may vary from one subject to the next.

The focus of this study was the use of multimedia technology in the teaching of grade three science. For this study, a multimedia resource was defined as a teaching resource that requires the availability of a computer and includes a combination of media in one learning resource. The combination of media could include text, audio and video representations, graphics, animation, simulations, hyperlinks to the Internet, and interactive learning activities. The Zoology Zone multimedia resource used in this study meets all the criteria in this definition of multimedia. The Zoology Zone multimedia resource was in the format of two CD-ROMs. Students required both the CD-ROM software and a computer to utilize the multimedia resource.

Science Education

The current Alberta Elementary Science Program of Studies, replacing the 1983 elementary science program, was issued in 1996. Alberta elementary schools were mandated to have the new science program of studies in place by September 1996. The philosophy of the 1996 program was built on the following principles which are stated in the program of studies: (a) children's curiosity provides a natural starting point for learning, (b) children's learning builds on what they currently know and can do, (c) communication is essential for science learning, (d) students learn best when they are challenged and actively involved, and, (e) confidence and self reliance are important outcomes of learning (Alberta Education,1996, pp. 1-2). The philosophy of the program was to be reflected in the teaching of a total of five topics, commonly referred to by teachers as units, in each grade. Each topic is presented in terms of: (a) an overview, (b) general learner expectations, and (c) specific learner expectations.

For each grade, there are specific attitudes that are to be developed across all five topics studied. General and specific learner expectations are listed in the program of studies to guide the teacher in planning for instruction that will encourage students to develop positive attitudes for the study of science and for the application of science in responsible ways.

For each grade, there are two areas of skill emphasis. Four topics focus on 'science inquiry skills' and one topic focuses on 'problem solving through technology.' Topics with an emphasis on science inquiry skills require that students address questions about the nature of things and seek answers through exploration as well as focussed investigation. Ebenezer and Connor (1999) suggest that these skills include collecting evidence (i.e., observing and classifying), generating questions (i.e., predicting and inferring) and preparing and discussing explanations (i.e., interpreting). In the problem solving through technology topic, the emphasis is on practical tasks which involve students in constructing and doing things to meet a given need. The outcome is intended to be a product or process that is useful (Alberta Education, 1996). In this research

study, teachers taught the Animal Life Cycle topic. This is one of the four science inquiry topics in the grade three program.

For each topic in a grade, there is a listing of general and specific learner expectations (SLEs) for Understandings. These are often referred to by teachers as the 'content' portions of the program in that they define specific learner expectations orientated to what students should be able to do with respect to displaying learning. Embedded in each topic of study are 'key ideas' or concepts which students begin to recognize in their science learning. These 'key ideas' (Rowell & Gustafson, 2000) may be linked together, over many units of study throughout elementary school, to form overarching 'big ideas'. Rowell and Gustafson (2000) point out that these are general concepts which help students to construct a meaningful understanding of the natural world and human action in it.

In the teaching of elementary science, teachers need to incorporate the philosophy of the science program in all teaching. They also need to design instruction that has a science inquiry focus and meets the requirements of the curriculum in the development of student attitudes, and the teaching of basic understandings in each topic of study.

The teacher's activities and interventions, attitudes and training can have a significant impact on the science learning (Driver, Asoko, Leach, Mortimar & Scott, 1994). The role the teacher serves in teaching science is pivotal in the child's development of scientific knowledge. For example, in the teaching of spiders as part of the grade three Animal Life Cycle topic, a teacher's personal view of spiders can influence student learning. A teacher who is fearful of spiders may inadvertently plan activities that contribute to the development of student attitudes that may not be consistent with a disposition to inquiry. As teachers in Alberta implement the science program of studies, they wrestle with challenges to identify and implement teaching strategies that best encourage science learning by elementary children.

Teacher Learning

Professional development of teachers is an important dimension in the integration of technology and in science education in Alberta schools. It is important to respect how teachers learn and to develop professional development programs that provide teachers with the support, information and skills they need to integrate technology in classroom teaching.

Hardware has become more accessible in schools but improvements have been slower in development of high quality software and the identification of pedagogy required to utilize available hardware and software in effective teaching of the instructional program. As teachers learn more about the possibilities for student learning with multimedia resources, they can design learning environments that capitalize on those possibilities. Hooper and Rieber (1995) point out that there is a difference between technology used to support traditional classroom activities and technology used to create the best learning environments possible for students. It is misleading and potentially dangerous to focus on hardware and software while failing to consider how to integrate technology in teaching in a way in which the learning environment engages students in learning (Hooper & Rieber, 1995).

In Alberta, many teachers have had the opportunity to learn about using technology and software through in-services which have focussed on the technical aspects of computers and on the basic use of application software. This concentration on the 'how to' type of information does not equip the teacher with the knowledge, skills and attitudes needed to alter instruction to effectively integrate technology in teaching. It is problematic to assume that, as schools have more hardware and software, the teachers will be able to use the technology to enhance learning. Some teachers are not well prepared to teach in a technological environment. If they attempt to use the technology without examining and adapting their teaching approaches, frustration and a reluctance to embrace further growth in the integration of computer technology into classroom instruction can result.

The need to support teachers in professional development is also true in the implementation of the Alberta Elementary Science Program of Studies. Teachers require support in learning appropriate methods to teach science. Professional development in this area involves identification of teaching strategies that: (a) address the philosophy of the science program, (b) support the program emphases on the development of skills for science inquiry and problem solving through technology, (c) encourage the development of the attitudes of science, and (d) focus on the understandings identified for each topic of study.

If teachers have an understanding of effective pedagogy, they can be enabled to exercise professional discretion in the selection of instructional practices that address the expectations of the Alberta curriculum and that are also consistent with research on children's learning of science and technology.

Context of the Researcher

I have developed an interest in the areas of technology education and science education as a result of my professional experiences during my career as a teacher and educational administrator. I have been a school principal for 16 years and worked with elementary students and teachers for 13 of those years. In 1991, I was responsible for the opening of a new school that was designed with a focus on technology integration. The teachers selected to work at the school were committed to the mandate to integrate technology into the teaching of all elementary grades. The school had the latest technological innovations and a talented staff eager to learn how to effectively utilize the technology in teaching elementary students. In my capacity as an elementary school principal, I provided relief time for homeroom teachers. This gave me two years experience teaching the grade three science program. I recall being frustrated with the 1983 science curriculum because it did not provide me, as a non-science trained teacher, with sufficient knowledge and direction, to confidently teach the program to grade three students. I had to develop my own units and determine much of the content and skills to be taught. I volunteered to sit on an Alberta Education needs assessment committee that was identifying concerns of

elementary science teachers. When the 1996 science program of studies was completed, I was pleased to see that many of the recommendations made at the needs assessment meetings were incorporated into the new program of studies. In my role as a supervisor for instruction and as a classroom teacher, I felt that I shared a common understanding with teachers about the challenges they faced in teaching science and in teaching technology. These concerns led to my involvement with the Zoology Zone Project.

I enjoyed the opportunity to be part of a team of five elementary teachers who developed Zoology Zone: Investigations of the Animal Kingdom, a set of three CD-ROM multimedia resources for use in the teaching of the 1996 Elementary Science Program of Studies (see Appendix A). The CD-ROMS were titled: (a) Spiders, (b) Bears, and, (c) Raptors. The project was initiated as an outcome of two concerns expressed to me by several teachers in the school in which I was principal. Teachers made requests for appropriate resources that could assist them in the integration of technology in classroom teaching. They also requested resources that would assist them with the implementation of the 1996 Elementary Science Program of Studies. In my capacity as a school principal, I developed a proposal to address these teacher concerns and forwarded the proposal to Alberta Education. The outcome of the proposal was the awarding of an innovation grant to develop a multimedia teaching resource that would be useful in the teaching of technology and in the teaching of elementary science.

A partnership was formed to carry out the project. The partners included my school district, Alberta Distance Learning, a film company and a multimedia corporation. My role, as instructional content leader, involved co-ordinating the development and production of the educational content for the resource. The opportunity to be involved in the production of these resources has made me aware of the potential for effective use of multimedia resources in elementary classrooms but it has also made me aware of the questions and challenges that educators encounter with the use of multimedia resources (e.g., teacher frustration with technical problems when using technology, lack of suitable

software for young learners). After five years of hard work, the three CD-ROMs were completed. In November 2000, they were approved as a learning resource by Alberta Learning and marketed for public sale.

I hold the following assumptions about the topics in this study that may have influenced my interpretation of findings:

1. The Zoology Zone multimedia resource has a place in the elementary program of science studies. I cannot dismiss that my long-term involvement as a content developer influences my opinion of the resource.
2. Multimedia technology can be effectively integrated into the teaching of elementary school science.
3. Student learning can be positively influenced by multimedia teaching resources.
4. Teachers want to learn how to integrate technology in their teaching.

In this research study I worked with a group of teachers who shared my interest in multimedia resource use in elementary science classrooms. They also had a desire to examine their practice as teachers and were willing to explore with me their experiences with the Zoology Zone Spider and Bear CD-ROMs in their grade three science lessons.

Applications for Technology Integration

The Zoology Zone multimedia resource was designed by teachers for use by other Alberta teachers in the teaching of the grade three science topic on Animal Life Cycles. The Zoology Zone multimedia resource was designed as a tool for technology integration that would serve as a computer assisted instruction resource. Each CD-ROM is divided into five learning zones: (a) "All About Me", (b) "How I Grow", (c) "Where I Live", (d)"How I Eat", and (e) "Did You Know". Each learning zone includes a variety of learning activities that could be used to teach the Animal Life Cycle topic (see Appendix A). In each learning zone there are a variety of learning activities that the program developers designed to appeal to young students. Each learning zone has the following elements incorporated into the learning activities: (a) content that has been reviewed by experts, (b) video clips and slides of animals in natural settings, (c)

interviews with Alberta experts on common questions about the animals of study, (d) use of animation and cartoons, (e) games to stimulate the learning of concepts and to develop some science inquiry skills (e.g., inference, prediction, and observation), (f) music and lyrics, (g) activities that integrate with language arts, social studies and art, (h) interactive learning activities that provide immediate feedback to students, (I) random generation of alternatives in each game so that every time a student plays a learning game the experience is different, (m) suggestions for learning activities to be completed in the laboratory or field settings, (n) hyperlinks to the Internet to sites that are appropriate for grade three learners, (o) glossary of terms, and (p) use of student actors and humor.

The Understandings from the prescribed curriculum were used as the starting point to develop many of the student learning activities (see Appendix B). The three other emphasis areas of the 1996 science curriculum including philosophy, skills for science inquiry, and attitudes were also considerations in the development of many of the learning activities in the multimedia resource. In the section of each CD-ROM titled Explorations there are a variety of student activities that must be completed in a classroom lab setting or in a fieldwork environment (e.g., park, playground, or zoo). These exploration activities require the application of science inquiry skills and include the collection of data, carrying out investigations, and a variety of other learning activities in which students explore the topic of Animal Life Cycles. The developers of the multimedia resource included learning activities encompassing all the SLEs for the understandings identified in the Animal Life Cycle topic. In regards to the other SLEs in the science curriculum, the developers of the multimedia resource stated in the teacher guide for the resource, that the teacher approach to utilizing the resource was important in determining the extent to which all areas of emphasis in the 1996 Elementary Science Program of Studies were taught.

The Zoology Zone multimedia resource could also be helpful for teachers in addressing the Alberta Information and Communication Technology (ICT) outcomes. The Zoology Zone multimedia resource could be utilized to integrate

many of the identified information and communication technology outcomes at the same time that the objectives in the science topic were being addressed. Exit competencies for Division One, grades ECS – grade 3, are identified in the ICT outcomes (see Appendix C). As students used the Zoology Zone multimedia resource, they indirectly addressed many of the outcomes identified in the ICT outcomes.

The Zoology Zone multimedia resource could also be used as a cognitive tool for learning. The instructional design of the program could serve as a springboard to other learning activities, using other computer application programs (e.g., Kid Pix or HyperStudio) in which students could create their own multimedia presentations using the design of Zoology Zone as a template. Also, some of the suggestions in the Zoology Zone teacher guide point to follow up learning activities in which students collect data and organize it using spreadsheets or databases. In these instances where the student can access the data in a variety of ways and manipulate the data, the technology is being used as a cognitive tool.

Research Study

Purpose of the Study

The purpose of this study was to explore teachers' experiences with the Zoology Zone multimedia resource in the elementary science classroom. Through conversation and collaborative interpretation with teachers, I set out to:

1. Explore teacher experiences with the use of the Zoology Zone multimedia resource in the teaching of the Animal Life Cycle topic in the grade three science program.
2. Gain a heightened awareness and deepened understanding of teacher needs in the teaching of science using multimedia technology.

Research Inquiry

What are teacher experiences with the Zoology Zone multimedia resource in the teaching of grade three science?

The research was guided by the following questions:

1. How do teachers describe their learning experiences using the Zoology Zone multimedia resource in the teaching of the grade three Animal Life Cycle science topic?
2. What challenges do teachers discover in the use of the Zoology Zone multimedia resource in the teaching of the elementary science program?
3. What do teachers identify as helpful skills, knowledge and attitudes when using a multimedia resource?
4. What do teachers identify as useful assistance in the use of a multimedia resource in the teaching of grade three science?
5. How do teachers view multimedia resource use in science learning by students?
6. What are teacher beliefs about technology and science education?
7. What are teacher views about student learning and multimedia resources?

Significance of the Study

Teachers have concerns related to science teaching and multimedia technology teaching in the grade three elementary classrooms. Findings from my study advanced an understanding of multimedia technology use in science education by:

1. Contributing to guidelines for teachers in the integration of multimedia technology in science teaching.
2. Creation of an awareness and understanding of teachers' experiences with multimedia use in teaching of grade three science.
3. Providing educators with examples of practical applications of multimedia technology in elementary science classrooms.

Overview of the Dissertation

This dissertation is organized into seven chapters. Chapter One has provided an introduction to the three dimensions of the study. Chapter Two presents a review of the literature related to the three dimensions of the study: (a) technology as a teaching resource, (b) science education and constructivist pedagogy, and (c) teacher learning. Chapter Three describes the design of the study and situates the study within the field of qualitative research. Chapter Four is the description of the research study and presents the participants in the study. This chapter also describes the experiences of the four teacher participants from data collected during individual interviews and classroom visits. Chapter Five presents the findings from the group interviews and provides the collective story of the study. Chapter Six, the discussion of findings, presents the three dimensions of the study as they relate to the research questions of the study. Chapter Seven presents implications from the study for consideration by three stakeholder groups in education.

CHAPTER TWO
LITERATURE REVIEW

Introduction

This literature review provides a theoretical orientation for the study: It addresses literature from the topic areas that inform the study. I have organized the literature review under three headings: (a) Technology as a Teaching Resource, (b) Science Education and Constructivist Pedagogy, and (c) Teacher Learning and Technology.

The relationships between these three topics and the research study are addressed in the review.

Technology as a Teaching Resource

Making computers and other technology available in classrooms does not ensure these learning tools are enriching student learning. The teacher role is critical in developing the learning environment and guiding the use of the technology in that environment. Teachers need to understand technology in order to develop effective strategies for teaching with technology in order to facilitate student learning.

The Alberta ICT outcomes involve teaching students about technology, about the role it has in society and how to use and apply a variety of technologies to learning. The ICT outcomes state that technology is best learned within the context of application and that students, through appropriate classroom learning activities will learn:

1. that, although technology is often complex, it is simply 'a way of doing things'
2. about the impact of technologies in their lives and workplaces
3. how to determine which processes, tools and techniques to use, and when to use them
4. how to use and apply a variety of information and communication technologies to problem solving, decision

making, inquiring and researching in the context or other subject matter. (Alberta Learning, 2000, p.1)

The use of computer technology to address ICT outcomes teaches students about technology and how it can be used to alter human activity. Technology is having a significant impact on society and for this reason students must learn to understand and apply it in effective and ethical ways. This can be done by integrating technology learning with other learning (Recesso & Carll, 1999).

The Alberta ICT program of study identifies learning outcomes in three general categories: (a) foundational operations, knowledge and concepts, (b) processes for productivity, and (c) communicating, inquiring, decision making and problem solving. The classroom teacher has considerable freedom in determining how to design instruction to meet the general outcomes. A discussion of the more common applications of technology to meet these outcomes follows.

Applications of Technology in Teaching Elementary Students

In the elementary classroom, technology use is usually focused on three types of applications. Firstly, technology can be used to assist the teacher in instruction of the program of studies, often referred to as computer assisted instruction (CAI). Secondly, technology can be utilized as an information and communication tool. Thirdly, technology can be used as a cognitive tool for learning. Each of these applications of technology is discussed further to frame the placement of the Zoology Zone multimedia resource in the research study.

Computer assisted instruction is "any use of a computer to present instructional material, provide for active participation of the student, and respond to student action" (Hefzallah, 1999, p. 116). Lockard and Abrams (2001) describe CAI as an application of the computer as an instructional tutor, a tool for learning specific things. Characteristics of CAI include student interaction and flexibility. The computer becomes a sort of private tutor in which the learner is actively engaged with the computer, responding to prompts and questions and receiving feedback throughout learning activities. Each learner has considerable flexibility

to choose how to proceed through learning activities. CAI has been classified into categories of drill and practice, tutorials, simulations, games and problem solving activities. Key in the definition of CAI is the word 'assisted'. According to Lockard and Abrams (2001), CAI should not be a stand alone teacher resource; the teacher must carefully devise ways to integrate CAI into instruction. CAI has proven to be very effective in promoting student learning when used appropriately.

> Under the right circumstances, CAI has shown positive achievement gains, learning in shorter periods of time than traditional instruction, longer retention of content learned and a more positive attitude on the part of the student toward the learning process. These results are encouraging and provide support for the use of CAI in our classrooms. (Lockard & Abrams, 2001, p. 222)

A second use for computer technology in schools is the application of the computer for gaining information and for communicating (e.g., word processing, Internet use). This application of technology use is commonly used in classrooms and may include student use of technology to locate information, carry out research on an assigned topic, and present information using basic word processing, drawing, spreadsheet and database software.

The concept of utilizing the computer as a cognitive tool is a popular perspective on effective technology integration in schools. Jonassen (1996) is an advocate for using the computer as a tool for helping learners organize and represent what they know. He states that the computer is being used as a cognitive tool when the computer is used to engage learners in meaningful cognitive processing of information that extends the thinking processes of learners. Cognitive tools provide a vehicle that helps in generating thoughts that would be difficult without the tool (Jonassen, 1992). For example, for the young learner, the computational abilities of a spreadsheet and database allows generation of new information through student manipulation of data. Jonassen states that using the computer, as a cognitive tool, is a constructivist approach because learners are actively engaged in the construction of knowledge and presentation of that knowledge. Jonassen (1992) suggests that cognitive tools

are learner controlled and not teacher or technology driven. He explains that the cognitive tool approach provides an environment that requires students to think harder about what they are studying and to construct new realities based on their experience. Von Blanckensee (1999) suggests that young students can also utilize multimedia tools as cognitive tools in creating multimedia projects where they enjoy demonstrating in a variety of creative ways what they have learned (e.g., student report that includes text, graphics, video, and audio).

The study of multimedia resources, as one type of software, is viewed as a subset of the larger study of technology and education. Research has identified various themes related to teaching using computer technology. In regards to the specific dimension of multimedia technology use, in the teaching of young children, the research is limited. The literature related to the use of multimedia resources in teaching suggests that teachers need to examine the value of multimedia in their teaching assignment and to determine their role as teaching resources. This literature also addresses pedagogy that is appropriate for helping students to effectively utilize multimedia resources.

Multimedia as Teaching Resource

When selecting a teaching resource, teachers investigate the relevance of the resource to the intended learning objectives. When teachers consider a multimedia teaching resource, they need to explore the influence it could have on student learning. The value of the multimedia resource to the teacher is affected by the content of the resource and the way in which students will use the resource. The way in which a multimedia teaching resource contributes to achievement of the learning objectives in a unit of study needs to be assessed before decisions are made to utilize a multimedia resource in teaching.

Teachers need to select technology teaching resources that are developmentally appropriate for learners and that effectively presents lesson content (Haugland & Wright, 1997). Software should be open-ended and allow children flexibility to explore and discover, take risks, problem solve and control navigation and pacing. When appropriate software is integrated across several

subject areas, rather than divided by discipline or topic, students can gain skills and knowledge in a variety of developmental areas (Haugland & Wright, 1997). Haugland, (1997) states that computer based resources for young students should reflect the interests and needs of the students in the classroom and be easy to operate. The resources should help children to build on their development of language, critical thinking and social skills and help students to construct relevant up to date knowledge of the world.

Von Blanckensee (1999) points out that a multimedia resource used effectively in elementary classrooms can support children's development in oral and written language in mathematics and science activities. For example, students using a multimedia resource on spiders acquire a visual image of spiders and develop a vocabulary about spiders that can be applied to written and discussion activities that may follow exploration of the multimedia resource.

Von Blanckensee (1999) explains that learning with multimedia resources and student creation of multimedia projects can incorporate multiple intelligence theory into classroom practices by supporting varied student learning styles. Armstrong (1994) provides examples of how the use of multimedia resources in classrooms of young students can support learning through the intelligences. Linguistic intelligence is appealed to by the written text in multimedia resources. The audio and sound capabilities of multimedia appeal to musical intelligence. Illustrations and the presentation of phenomena from different perspectives as well the ability to manipulate the images presented on the computer screen facilitate spatial learning. When teachers are employing constructivist pedagogy and organizing instruction to encourage interaction between students, interpersonal intelligence is stimulated. The development of student made video sequences and student observation of video clips can appeal to the bodily and kinesthetic intelligence (Armstrong, 1994). When multiple intelligence theory is utilized in developmentally appropriate ways in computer-based classrooms, research has shown significant student gains in non-verbal skills, structural knowledge, long term memory and complex manual dexterity (Haugland & Wright, 1997).

There is considerable support for the viewpoint that multimedia resources can motivate students and provide rich, constructive and critical learning environments.

> Multimedia is heralded as an ideal learning environment because it is student centered, project oriented, multi-sensory, interactive and lends itself to collaborative learning. Enthusiasts note that multimedia reverses the teacher as sage on the stage humdrum by putting tools in students' hands so that students can construct meaning from elements that combine graphics, sounds, and words. (Madian, 1995, p. 16)

Computer technology appears to assist in motivating students to learn. However, motivation for learning can be attributed to many factors, and Clark (1994) cautions educators to critically assess the role the technology exerts on student motivation. Students may be responding to novelty effects of the technology or to one particular presentation approach in the technology. Neither of these factors may sustain the learners' interest over an extended period of time. Clark also cautions multimedia advocates that the benefits attributed to the combinations of media providing learning benefits are not any more significant than learning benefits from one preferred style of teaching. However, multimedia, which is conveniently packaged in one teaching resource, may include multiple types of media and several approaches to instruction. It may be that the motivation for a particular student is enhanced by one preferred style of instruction or by the combinations of possibilities. Lookatch (1995) argues that many of the benefits claimed in research on multimedia instruction are in error and that some of the stated motivational effects and preferences of multimedia are a charade. He points out that teachers need to assess the effects that a multimedia resource may be having on student motivation.

A number of studies have found that student enthusiasm for learning is created with the use of interactive multimedia software (Dockterman, 1995). However, Dockterman argues that interactive software should be used in a classroom in a way that sparks thoughtfulness and student interaction by either getting the students to generate a conversation with others or by motivating the students to think further about the phenomena of study. Interactive software can

also be used to create passive learning environments, but that is not the best use of the interactive resource nor the best environment for student learning. Dockterman illustrates the importance of student interaction in his assessment of one classroom where students demonstrated high levels of learning using interactive multimedia resources:

> But students are not just pushing buttons. They're talking to one another. And that's where the magic lies. Interactive technology is neat, but ultimately, it is interactive classrooms that bring the real breakthroughs in learning. (Dockterman, 1995, p. 59)

Wiburg (1995) cautions educators to critically assess whether multimedia or any technology application specifically improves learning and to be cautious in crediting computers and multimedia with anything more than being simple tools to assist the teacher with instruction. It is the instructional strategies provided by the teacher guiding students through computer activities that improves achievement (Lookatch, 1995; Haugland & Wright, 1997). The role of the teacher is critical in the selection of multimedia resources and in the implementation of teaching strategies that complement the use of multimedia resources.

Brown and Henscheid (1997) report that uses of multimedia and Internet resources can be used to provide interactive learning activities as well as multiple presentations of information. Student engagement with this type of technology is significant when there is variety in the materials and presentation style.

Pedagogy and Multimedia

The use of a multimedia teaching resource is influenced by pedagogy. There is support in research that certain teaching strategies contribute to student learning in an environment where computer technology is utilized.

Using constructivist approaches requires the teacher to make the transition from teacher as information giver to the teacher as a coach or guide to learning. The role of the teacher in a constructivist classroom involves determining what students already know and challenging students to question their thinking and to support their conclusions (Sage & Torp, 1997). Miller and Olson (1995) caution

that the voices of all teachers, not just technology supporters, must inform how technology is used in the classroom and that the teacher should be in charge of what happens with technology in the classroom.

A recurring theme in research on student learning with technology indicates support for instructional strategies that address the social dimensions of learning. These include teaching activities that promote peer tutoring, small groups and co-operative learning strategies. Students benefit cognitively and socially from working in small groups while working at a computer (Hooper & Reiber; 1995, Von Blanckensee, 1999). Gains in improved attitudes and often improved achievement should encourage educators to consider peer tutoring, small groups and cooperative learning strategies in computer based lessons. Haugland and Wright (1997) found that young children could work at computers in small groups and frequently preferred to work with a peer rather than working alone.

Promoters of computers in the education of young children argue that computers connect people (Haugland & Wright, 1997). This position supports the social dimensions of learning in that students utilize computers to communicate and interact with others in the classroom environment. Caine and Caine (1997) write about the classroom as a community where what is learned has meaning for the community. Students derive meaning from their participation as learners in the classroom community. Joyce, Weil and Showers (1992) also discuss the importance of communities of learners; the social nature of learners can be recognized through teaching models that utilize cooperative learning and other teaching activities involving interaction with members of the learning community. These approaches positively affect academic learning, social development, and the self-esteem of the learner.

Powerful learning gains are made when children work together in partners or groups.

> When children collaborate, they share the process of constructing their ideas, instead of simply laboring individually. The advantages of this collective effort are that children are able to reflect on and elaborate not just their own ideas, but those of their peers as well. Children come to view their peers not as competitors but as resources. Mutual tutoring, a sense of shared progress and shared

> goals, and a feeling of teamwork are the natural outcomes of cooperative problem solving, and these processes have been shown to produce substantial advances in learning. (Strommen & Lincoln, 1992, p. 3)

Technology use is most effective when it is used to provide learning environments in which the focus is learner centered and active learning is encouraged. When children are active learners, they actively explore their world and can, through a process of assimilation and accommodation, acquire and construct knowledge (Hooper & Rieber, 1995). Active learning environments allow the student to control and pace the action, to respond to, and to engage in making relationships between lesson content and prior knowledge. Children want to learn, experiment and discover. Bitter and Pierson (1999) say that in classrooms where teachers integrated technology and were trained and experienced in providing student centered learning, the students displayed better attitudes toward school, students initiated more communication and the teachers had more opportunity for individualized instruction. In such classrooms, teachers can employ instructional strategies that capitalize on children's intrinsic motivation by allowing them to follow their own agendas, and to determine learning based on where the child wishes to go (Haugland & Wright, 1997).

When learners can make decisions and have some control over the learning process, they are motivated to learn. Further to this, when students do have some control over determining the learning process, they develop useful knowledge about learning strategies and increase their confidence in their capacity to learn new things, and to deal successfully with new problems (Hodson, 1998). Teachers can design instruction to include elements of student directed learning.

Chris Dede, noted author on educational technology, stated in an interview with O'Neil (1995) that the availability of software and computer technology can give students more ownership of the curriculum and more choice in what and how they study. He supports a constructivist approach to learning but acknowledges that teachers who try this approach are at risk of burnout because of the time and

effort required. He asserts that technology can provide a supportive infrastructure that makes it easier for teachers to use a constructivist teaching model.

Technology can have a liberating effect for teachers if classrooms are learner centered and if students and teachers use computer technology to create a learning community. Support for the use of idea technologies (i.e., using the computer as a tool in a variety of ways to gain new understanding) parallels constructivist learning approaches in that teachers utilizing idea technologies focus on utilizing the technology to assist students in building new knowledge and understanding as a result of the activities developed with the technology (Hooper & Rieber, 1995).

Play and experimentation are identified as powerful forces in the development of the child learning because they are self motivated processes of learning which encourage children to reflect on their ideas (Strommen & Lincoln, 1992). This feature of constructivist philosophy holds particular promise in the use of technology in classroom learning. When students are given an opportunity to explore a teaching resource and play with it on their own there are motivational benefits.

Multimedia resources open new possibilities in education and the potential of new learning environments is wide and promising although some of the special effects may be distracting to young learners and contribute to off task activity (Giardina, 1992). Some research indicates that multimedia technologies, with power to create lifelike images and interactivity, can sometimes make it confusing for young children to sort out reality and fiction (Wiburg, 1995). A student may experience information overload or become distracted from the intended learning objectives. Teachers may also get distracted from intended teaching objectives by becoming tempted to use a multimedia resource to do teaching that may be more effectively done in the classroom or science lab. The issues of providing adequate time for teachers to learn about multimedia and for students to use multimedia resources are also identified as potential drawbacks that need to be examined prior to using multimedia in instruction (Wellington, 1999).

Both Wiburg (1994) and Madian (1995) express caution about the use of multimedia resources. Madian indicates that educators should not use multimedia to replace what imaginative minds should be doing (e.g., sensing, picturing, visualizing). Teachers need to make careful choices about when multimedia is used and what role the teacher plays in student learning. Wiburg emphasizes the importance of respecting and recognizing what the learner brings to the learning environment and of using multimedia in ways that increase student control of learning.

Active learning environments need to be managed. A challenge for teachers is to guide students to use the freedom to explore (Marchionini, 1990). Students also need guidance in understanding the organization of technological media (e.g., hypertext, hypermedia) and benefit from learning strategies to locate information from which they can make their own connections (Wiburg, 1995). These strategies may include teacher explanations as well as strategies which help students in locating and organizing information. If students are given opportunities to create diverse pathways through a lesson, they often discover interrelationships that are meaningful to them but that would have been missed in more traditional representation of content (Hooper & Rieber, 1995).

Assessment of student learning in a technology-based constructivist environment should be done from a constructivist perspective (Norton & Wiburg, 1998). Assessment should address the values of constructivism including the nature of student cognitive functioning, the status of student relationships in the classroom, and the student construction of new understandings and acquisition of new skills. Norton and Wiburg (1998) state that assessment should be used as a service to the learner rather than as an accountability device. This can create a dilemma for teachers who may be expected to adhere to standardized tests and provide documentation for student achievement in ways that are not compatible with constructivist pedagogy.

Science Education and Constructivist Theory

Constructivist learning theory has been in the forefront of science education in the last two decades. The constructivist perspective of how students learn science points to instructional strategies for the teaching of science.

Learning Science

Driver et al (1994), working from a constructivist theory of learning, focus on the ways in which students' informal ways of knowing are introduced in the classroom. Driver et al present a view of the interplay among the various factors of personal experience, language, and socialization in the process of learning science in classrooms, and discuss the problematic relationships between scientific knowledge, the learning of science, and pedagogy.

Scientific knowledge is constructed and not transmitted (Driver et al, 1994). Learners build on what they know and then try to make sense of the ways in which they see the world. According to Driver et al, science knowledge encompasses the values of science, a familiarity with the language of science and an appreciation of the constructs of the scientific community.

As constructivist learning theory has gained acceptance in science education, there has been considerable effort to use the findings of research into children's preconceptions in science to inform teaching practice (Driver et al, 1994). One focus of this has been to work with teachers, to familiarize them with some of the pre-conceptions research, and to help them find ways to apply constructivist ideas about learning in their classrooms (Appleton & Asoko, 1996). Curriculum that is built upon constructivist beliefs must be concerned with how the student makes sense of experiences in relationship to the knowledge being acquired. Knowledge is created through social interaction as individuals test the fit or usefulness of their conceptual understandings in interactions with others and in the contexts in which the knowledge is applied (Appleton & Asoko, 1996).

Science teachers are challenged to move toward orientations to science that enable students to construct appropriate meaning. This may involve

challenging teachers to move towards a conceptual change orientation to science teaching (Smith & Neale, 1989).

> Teaching science involves eliciting children's ideas, providing discrepant events, challenging children to predict and explain, contrasting alternatives, presenting scientific conceptions, and providing ways to apply new concepts. (Smith & Neale, 1989, p. 11)

This approach to teaching is consistent with constructivist learning theory in that the focus is on provision of opportunities for the learner to construct and reorganize knowledge.

Hodson (1998) points to the need to develop an approach to the teaching science that takes account of students' existing views and the ways in which these views interact with and are modified by experience. He identifies three points about learners. First, learners are not passive recipients of knowledge; rather, they are active constructors and re-constructors of their own understanding. Second, learning depends as much on what the learner brings to the task as it does on what the teacher builds into it. The way students engage in classroom activities and how they interpret events and experiences are shaped by a variety of factors including prior knowledge and their experiences with the phenomena of study. Third, the restructuring that constitutes learning is a continuing process in which the student never stops learning.

Hodson (1998) discusses the personalization of science learning in his presentation of the multi dimensionality of critical scientific literacy. He asserts that there are three major elements in scientific literacy: learning science, learning about science and doing science. These are viewed as separate activities that are inter related and interdependent in science learning.

> With respect to these three major elements of science curriculum, personalization of learning means ensuring that: (a) learning takes account of the knowledge, beliefs, values, attitudes, aspirations and personal experiences of individual students; (b) science and technology are presented as more person-oriented and science/technology education is politicized and infused with sound human and environmental values; (c) every student has the opportunity to conduct scientific investigations and to engage in technological problem solving tasks of his or her own choosing and designing. (Hodson, 1998, p.5)

Driver et al (1994) address the social construction of science knowledge by explaining that scientific understandings are constructed when individuals engage socially in talk and activity about shared problems and tasks. Making meaning of science phenomena is a dialogic process involving persons in conversation, and learning is seen as the process by which individuals may learn from more skilled members. In the science classroom, the science teacher needs to be attentive to the social construction of meaning in addition to the individual construction. For example, one student in a classroom may be intrigued by spiders while another is fearful. The attitudes of both students during a classroom investigation into the study of spiders may influence the construction of meaning about spiders by other students in the classroom. Hodson (1998) states that meaning is negotiated, in part, through social interaction and that, in terms of school science, this means that teachers have to pay attention to socially constructed meaning and to the ways in which it changes over time and with experience, as well as to individual understanding.

Hodson (1998) summarizes an emerging consensus from the research on motivation that is helpful to teachers. He states that all learners have a need for experiences that generate feelings of accomplishment and that all individuals have a tendency to be motivated when they are enabled to focus on learning goals that are perceived as personally meaningful and relevant and meet the needs for autonomy.

Teaching Science

Brooks and Brooks (1993) provide a description of a constructivist classroom environment. Their focus on the actions of the teacher in a constructivist classroom is helpful in identifying elements of constructivist pedagogy:

1. Curriculum is presented whole to part with emphasis on big concepts.
2. Pursuit of student questions is highly valued.
3. Curricular activities rely heavily on primary sources of data and manipulative materials.

4. Students are viewed as thinkers with emerging theories about the world.
5. Teachers generally behave in an interactive manner, mediating the environment for students.
6. Teachers seek the students' points of view in order to understand students' present conceptions for use in subsequent lessons.
7. Assessment of learning is interwoven with teaching and occurs through teacher observations of students at work and through student portfolios.
8. Students primarily work in groups. (Brooks & Brooks, 1993, p. 17)

Although the research on science education for elementary students supports a constructivist approach to learning science (Hodson, 1998), developing teaching strategies has not been straightforward. Hodson suggests that it is useful to encourage teachers to recognize the social context of the classroom by providing learning environments that personalize learning for students and facilitate their construction of knowledge. This involves creating learning environments that incorporate the social dimensions of learning.

Constructivist conceptions of teaching and learning assign primary importance to the way learners attempt to make sense of what they are learning, rather than the way they receive information (Krajcik, Soloway, Blumenfeld & Marx, 1998). This has implications for how teachers instruct in science classrooms. Krajcik et al suggest integrated and usable knowledge is possible when learners develop multiple representations of ideas and are engaged in activities that require the use of knowledge. The learning occurs in a social context, that is, learners interacting with other learners and drawing on the expertise of group members. One way to assist in developing these learning environments is to engage students actively in learning through project-based activities and through exploration of science issues.

Hodson (1998) points out that the teacher's role involves determining when it is appropriate to use open ended learning activities. It is also the teacher's role to determine when it is appropriate to implement time constraints and direct

student activities. The teacher must be sensitive to student responses and adjust instructional activities to provide optimal levels of challenge that encourage further student exploration but are not discouraging for the students. One tactic Hodson suggests is that teachers retain control of content, directing students to new areas of study as appropriate, while ceding control of learning methods or learning style to students.

Hodson (1998) encourages the principle of personalization to design learning experiences that are meaningful and useful to the learners. With younger students, one way to address the concept of usefulness is to pay attention to selecting topics that are relevant to the young students. The study of the environment, including the study of local flora and fauna, as one component of science study has advantages to elementary students because the study can be applied to the personal experiences of the young learners.

Constructivist approaches to teaching acknowledge the importance of creating opportunities for students to make their own ideas known, to share them with others, and to subject them to scrutiny from others (Hodson, 1998). The teacher can facilitate this by providing an initial focus for thought by posing a question of the day or stating a problem, by conducting a demonstration, or showing a video, or by involving students in an activity of some kind. The teacher, through skilful questioning, discussion or various written student activities, can promote student responses and interpretations. The teacher in encouraging sharing of student ideas, plays an important role in inviting student involvement and developing in students a sense of ownership essential to building intellectual independence (Hodson, 1998). Furthermore, opportunities to support students in conceptual change are possible as students share ideas with the teacher and other learners. The teacher can assist students in modifying and developing their personal framework of understanding in order to include accurate aspects of scientific meaning.

'Key ideas' are useful for teachers to plan for science inquiry. They provide a general focus in inquiry that assists the teacher in interpreting the science curriculum and planning for instruction. "Key ideas are at the very heart

of scientific inquiry. These ideas structure what people look for and how they go about investigation in the realm of the natural world" (Ebbers & Rowell, 2000, p. 3).

Although 'key ideas' are not clearly stated in the Alberta Elementary Science Program of Studies, they are embedded in each topic of study and should be utilized by teachers in the structuring of science lessons. Furthermore, teachers should be attentive to the value of students linking 'key ideas' with other units of study so that the 'big ideas' in scientific inquiry are included in a child's science education. For example, in the grade three Animal Life Cycle topic, students may carry out a scientific inquiry into spiders. They may meet the SLEs pertaining to animal body parts, habitat and animal growth. The key idea in this inquiry (Rowell & Gustafson, 2000) may be "Animals have features which enable them to meet their needs." Over time, as students link this key idea with other science learning, they begin to construct an understanding about the 'big ideas' of change and diversity in the animal kingdom (Ebbers & Rowell, 2000).

Students learn by building on what they know and they may have to deconstruct everyday reasoning that they have acquired that contradicts science constructs. Nelson (1999) supports this view and emphasizes that students come to science classrooms with many of their own ideas, some of which are accurate science representations and others that are not. The challenge for the science teacher is to determine the preconceptions of students while engaging students in the topic of study. The constructivist approach must be attentive to the need to identify entry points for students and to provide opportunity to build knowledge and understanding from foundations of understanding that are respectful of the science discipline. Hodson (1998) suggests a variety of methods for determining students' entry points, including use of interviews, classroom observations, tests, concept maps, student diaries, and questionnaires.

The constructivist approach can be challenging for teachers. Often teachers do not hold constructivist views on learning which means that, in order to adopt constructivist teaching approaches, teachers have to change their existing beliefs and practices. Furthermore, teachers of science are often not well

prepared in science education, so their confidence in addressing constructivist teaching and challenging student preconceptions in science teaching is weak (Ryks-Szelekovsky, 1993). Smith and Neale (1989) report that students in science often fail to understand basic concepts. One cause of this is that teacher beliefs about science concepts may be in error and this inaccurate information is passed on to students.

Constructivist pedagogy focuses on the social dimensions of learning. The emphasis on cooperative learning and discussion based activities provides children opportunities to build on existing knowledge and construct new meaning. However, in an elementary classroom there are usually at least twenty students, with a variety of academic abilities, motivations, and learning styles. Osborne (1996) states that the social learners show strong preferences for group activity but that it is not a preferred learning environment for students with other learning styles. In this regard, widespread use of constructivist pedagogy may not be compatible with the learning styles of all students in a classroom.

There are limitations to constructivist pedagogy in relation to the elementary classroom. Constructivists advocate the need to structure learning so that it is active and in doing so fail to recognize that there is a role for telling, showing and demonstrating (Osborne, 1996). There are ideas in science (e.g., earth spinning) that children have difficulty in constructing meaning because the concepts are not common sense. In such instances, in the absence of the teacher telling or showing, the child experiences difficulty in gaining a scientific understanding. An argument exists in these circumstances to support direct teaching. The prescribed curriculum, time limitations for instruction, and the pressures of standardized testing also contribute to the practicality of occasions for direct teaching.

Becoming a constructivist teacher is not simple. It requires continual ongoing analysis of both curriculum planning and instructional methodologies as well as reflective practices for which most teachers have not been prepared. The pathway to becoming a constructivist teacher is influenced by the teacher experience with teaching, teacher knowledge about the curriculum, teacher

knowledge of student learning, and teacher confidence as well as deeply held beliefs the teacher may have about teaching and learning (Brooks & Brooks, 1993). The process of developing effective constructivist pedagogy takes time and commitment.

Alberta teachers have a mandate to meet obligations set out by the governing bodies for schools. They must be sensitive to balancing approaches to teaching that they view as best for student learning but that also meet the expectations for student achievement as determined by the provincial department of education. Teachers need to critically review the role that constructivist pedagogy can have in classrooms in Alberta.

Science Teaching and Technology

Science teachers face increasing demands to teach more content in the science curriculum while teaching science inquiry. Edelson (2001) states that by taking advantage of computing technologies, teachers can design science inquiry activities that also contribute to content learning. Technology can play a role in supporting science inquiry learning. Edelson (2001) presents several examples of technology that can contribute to science inquiry teaching strategies. Technology tools that 'simulate' natural processes can serve as demonstrations of events that elicit student curiosity. Simulation tools enable students to observe natural processes that may be impossible to observe in classroom settings and may assist students in observation of science phenomena that contributes to student construction of knowledge. Tools that allow students to design or construct artifacts can support meaningful application of knowledge which contribute to student's refinement of their science knowledge.

Edelson (2001) explains that technology has the potential to provide students with tools for investigation, knowledge construction, expression and record keeping. Given the challenges to science teachers to teach more content and have students engage in scientific practices, careful use of technology could assist science teachers.

Craig (1999) points out that the new generation of students, which she refers to as the 'Net-Generation', are technology literate and naturally engage in self generated inquiry when given the opportunity and assistance to explore technology learning resources.

> By allowing students choice, involving them and their interests in the learning process, and making resources available for inquiry, classrooms become not only a window to the outside world, but also a pathway for acquiring new knowledge and connecting the science classroom with technology and curriculum areas. (Craig, 1999, p.32)

Integrating multimedia resources into science teaching may result in benefits such as the encouragement of positive attitudes and motivation of pupils, increased learning through visualization, and increased variety in instructional approaches (Wellington, 1999). Clark (1992) found that when technology was used in science teaching to illuminate scientific phenomena and to permit students to manipulate the illustrations of the phenomena on a computer screen that there were improvements in children's abilities to notice parts of the phenomena. When children observed phenomena through the special effects of magnification and animation, they were more able to attend to cues and change their visual perspectives. Technology in teaching may influence student construction of knowledge by providing students with an additional way to view phenomena presented in science lessons.

Teacher Learning and Technology

According to Fisher, Dwyer, and Yocum (1996), the major challenge to supporting student learning with technology lies not with the technology but with the professional development of teachers. Unless we educate the teachers, classroom computers will remain overpriced word processors, and multimedia encyclopedia use will be the primary utilization of technology (D'Ignazio & D'Ignazio, 1998). Marcinkiewicz (1993) reports a great deal of support by government, academia and politicians for computer technology in schools because of the view that computer technology could have a major impact on the education system. However, Marcinkiewicz also states that teachers often under utilize computers that are available in schools. This points to the need to

address appropriate education of teachers in the effective use of computer technology.

There is a serious need to address the teaching of teachers if computer technology is to be effectively implemented in schools. Technology education is a mandate for Alberta teachers and professional development is one key to enabling teachers to integrate technology in a way that is supportive for student learning. Assistance for teachers to learn about technology for teaching is influenced by: (a) developing a positive climate for teacher learning, (b) establishment of an infrastructure for learning, and (c) provision of a structure for professional development.

Positive Climate for Teacher Learning

Teachers must continue to view themselves as learners if they are to experience professional growth as educators. Brooks and Brooks (1993) found that teachers who continued to view themselves as learners, who asked questions about what they did in classrooms, who were willing and able to alter both content and practice as they pursued understanding and who treated students and their endeavors as works in progress, learned as teachers and encouraged their students to model similar characteristics.

Teachers must be given support to challenge deeply held beliefs about education and technology and given direction to confront their beliefs and construct new ways of viewing technology in education (Dwyer, Ringstaff & Sandholtz, 1991). In developing constructivist approaches to the use of computer technology, teachers benefit from opportunities to view these new approaches in classrooms (McKeown & Beck, 1999). Teachers also benefit from support in relation to the 'discomfort factor' (Joyce, Weil & Showers, 1992) that accompanies learning new repertoires. If support for their risk taking and their discomfort is not evident, then they may withdraw from the use of new teaching strategies. If this support is available in a school, teachers are encouraged to use technology for teaching. A school that develops a climate that encourages peer teaching provides support for effective teacher learning.

Infrastructure

Technical support, effective software, sufficient time for learning the technology and the existence of a climate that supports peer learning are critical in successful preparation for the use of computer technology. Key to teacher support is the availability of technical support, which includes teacher support in the use of hardware and software and the access to booking and using facilities (Wellington, 1999). Teachers are more likely to learn about technology integration if there is sufficient technical support and access to technology resources (Quinlan, 1996).

Structure of Professional Development

The structure of professional development for teachers is important in the development of learning about technology. Joyce and Showers (1995) point out that a primary goal of teacher professional development is to design professional development programs that enable teachers to learn knowledge and skills new to them and to transfer that knowledge and skills to active classroom practice. There are four types of outcomes for teacher development programs: (a) the knowledge or awareness of educational theories and practices, new curricula, or academic content, (b) changes in attitudes toward self, children, academic content, (c) development of particular teaching skills, and (d) transfer of training and appropriate use of new skills and strategies for classroom instruction (Joyce & Showers, 1995).

In order to meet the desired outcomes, the content of a professional development program must address the existing repertoire of teaching knowledge and skills. It may be that it is preferable for the teacher to refine existing knowledge and skills, or the teacher may have to add new knowledge and skills that is not being utilized in existing teaching approaches. Effective professional development should include attention to the following elements: (a) relevance to teachers, (b) provision of time for learning, (c) consideration for the entry level of teachers, and (d) provision of on-going support systems for teachers.

Teacher professional development must have purpose and relevance to teachers to be useful (Hawkins, 1994). Quinlan (1996) reminds readers that the enthusiasm for computer technology in the past often faded as a result of teaching resources and products that did not meet teacher and student needs. For example, in science education teachers could benefit from being informed of the added value potential of multimedia (Wellington, 1999) and how it may be relevant to science learning objectives. A multimedia resource assists with visualization of abstract concepts and provides the possibility to allow learners to work at their own pace and to control their own learning which in turn can enable the teacher to increase personal interaction with individual students, thereby serving a useful purpose in the classroom (Wellington, 1999).

Time is critical in the process of teacher learning. Learning about multimedia technology is an evolving process and sufficient time must be afforded teachers to be introduced to the concepts and gradually advance to the later phases of acceptance and utilization (Brown & Henscheid, 1997; Quinlan, 1996; Solomon & Solomon, 1995; Hooper & Reiber 1995). The Internet has become very widely used in schools as a technology tool. Gibson and Oberg (1999), in a study of teachers and their experiences with learning about Internet, also found that time was a key factor in teacher learning. They found that teachers needed sufficient time to learn and practice new skills.

Teachers need time to progress through stages of technology use. Hooper and Rieber (1995) present a model of this process. The model has five steps or phases: familiarization, utilization, integration, reorientation, and evolution. Hooper and Rieber claim that the full potential of any educational technology can be realized only when educators progress through all five phases as follows:

1. Familiarization phase: The teacher simply becomes acquainted with technology. It is a phase of initial exposure to information regarding technology.
2. Utilization phase: The teacher tries the technology in the classroom. The attitude of, " I'll give it a try" prevails. However, if there are difficulties in implementation the teacher may discard the technology because there is little commitment to the technology.

3. Integration phase: This is considered the "break through" phase in that it is the phase in which a teacher consciously decides to designate certain tasks and responsibilities to the technology, so that if the technology is suddenly removed or is unavailable, the teacher cannot proceed with the instruction as planned.
4. Reorientation phase: This phase requires that educators reconsider and reconceptualize the purpose and function of the classroom. The focus of the classroom is now centered on a student's learning, as opposed to the teacher's instruction. Teachers in this phase are open to technologies that enable this knowledge construction process and are not threatened by being replaced by technology. Teachers in this phase allow students to utilize technology in ways that may not be anticipated during the planning stages for learning.
5. Evolution phase: In this phase there is an understanding that the classroom learning environment should constantly change to meet the challenge and potential provided by new understandings of how people learn. Implicit in this phase is the understanding that the educational system must continue to evolve and adapt to remain effective.

(Hooper & Rieber, 1995, pp. 156-157)

The entry level of understanding and confidence of the teacher with computer technology affects the way in which the teacher will learn more about using multimedia resources. An awareness of and attention to the phases of technology integration can be used to develop professional development activities on technology use that are effective for teachers.

Professional development must be more than one shot workshops and must focus on the integration of technology in the curriculum (Wetzel, 1997). Wetzel (1997) also found that teachers benefited from guided exploration, collegial sharing of integration strategies and one to one support from technology specialists. Teachers require assistance in helping students effectively utilize technology tools to assist in the learning of objectives set out in the programs of studies mandated by Alberta Learning. Teachers may benefit from mentoring in their growth to becoming competent with computer technology. Opportunities to peer coach and tutor and the ongoing support from administration and other teachers in the learning process are essential to adoption of technology initiatives

(Brown & Henscheid, 1997; Albaugh, & Knight, 1996). Teachers require education, not simply training, in relation to computer technology (Caverly, Peterson & Mandeville, 1997). This involves collaborative guided practice in a supportive environment so that an appreciation how technology affects how students learn can be internalized.

Support for risk taking, opportunities for feedback and practice, and provision of appropriate incentives and rewards are further elements of effective teacher professional development (Albaugh & Knight, 1996). Teachers are more likely to experience positive learning experiences in environments when the criteria for effective professional development are met. The ACOT (Apple Classrooms of Tomorrow) developed a teacher development center model that addresses the role of change in teacher education (Fisher, Dwyer & Yocum, 1996). In the ACOT program a constructivist learning approach was utilized with significant support in resources, teams, mentors, practice, feedback and time for teacher learners to reflect, dialogue and converse about educational technology. The outcomes of the ACOT program have been promising and provide direction for developers of professional development for teachers of using computer technology.

Professional development activities should also address strategies for teachers to assist teachers in adapting their teaching styles. Technology has changed the role of teacher from a primarily centralized position to that of a decentralized position (Chin & Hortin, 1993). This means that the teacher acts more as a facilitator to students while they are engaged in learning using a technology resource rather than when in a direct teaching role. Change and how teachers adapt to change plays a significant role in addressing technology use, provision of professional development, and encouragement of teachers to examine new approaches to teaching and to address personal beliefs about technology and learning.

Use of multimedia resources in classrooms brings teacher control issues to the forefront. Because the nature of multimedia, there is considerable potential for students to direct their learning. As students take more control of learning,

teacher control diminishes. Teachers can benefit from professional development that assists them in dealing with this approach to increased student controlled learning.

Connelly and Clandinin (1988) identify different ways in which teachers learn. Teachers learn from being learners and by reflecting on their experiences as individuals, and as students in formal education settings. They also learn from the process of teaching, from students they teach, and from other teachers. These findings support the role of teacher as co-learners with students and with other teachers in the examination of multimedia use in science education. Giving teachers opportunity to learn with their students and to participate in sharing experiences with other teachers and educators can positively affect individual teacher professional growth. Hodson (1998) refers to the process of 'reciprocal teaching', which occurs when "students and teachers learn from each other and both benefit from an occasional reversal of roles" (p. 169). Joyce and Showers (1995) in their discussion of teachers on peer coaching study teams support the value of teachers working together to enhance student learning:

> Teachers learn from each other in the process of planning instruction, developing the materials to support it, watching each other work with students, and thinking together about the impact of their behavior on the learning of their students. The collaborative work of peer coaching study teams is much broader than observations and conferences. (p. 125)

These findings provide useful direction for educators in the promotion of teacher understanding and implementation of constructivist teaching models and of effective use of multimedia resources.

Chapter Summary

This chapter reviewed the literature on teaching with technology, science education and constructivist pedagogy, and teacher learning with technology. The findings in this chapter provide support for the use of multimedia technology in a constructivist approach to learning elementary science. The process to enable teachers to do this was informed by research on teacher learning.

CHAPTER THREE
RESEARCH DESIGN

Introduction

This chapter describes the design of the research study. I begin with a general explanation of qualitative research and establish that this study is a generic qualitative research study, as defined by Merriam (1998). Four grade three science teachers participated with me in an interpretive inquiry, which explored their experiences in using the Zoology Zone multimedia resource in teaching science. Through individual interviews with the teachers, I developed a deepened understanding of each participant's story as they used the multimedia resource in teaching the Animal Life Cycle science topic. During group interviews, the participants discussed their experiences with me and with each other. Through the group interviews, the individual teachers shared their personal stories with using the multimedia resource and through group discussion all participants developed new understanding about their own experience with the multimedia resource and about the experiences of the other teacher participants. The chapter concludes with a description of how I managed and organized the data.

Qualitative Research

There are many activities that define a qualitative research study. Denzin and Lincoln (2000) define qualitative research as:

> a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible through a series of representations including interviews, conversations, notes and recordings. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them. (p. 3)

The definition above assisted me in situating my research plan in the field of qualitative research. Qualitative research is an umbrella concept covering

several forms of inquiry that help us to understand and explain the meaning of social phenomenon with as little disruption to the material setting as possible (Merriam, 1998, p. 5).

Qualitative researchers are primarily interested in understanding the meaning people have constructed, that is, how they make sense of their world and experiences they have in the world (Merriam, 1998). There are four essential characteristics common to qualitative research: (a) understanding the phenomenon of interest is from the participants' perspectives, not the researcher's, (b) the researcher is the primary instrument for data collection and analysis, (c) the research usually involves fieldwork in which the researcher observes participants in a natural setting, and (d) the research primarily employs an inductive research strategy (Merriam, 1998).

Qualitative research engages the process of curiosity and discovery to enable the researcher to better understand the perspectives of the participants involved in the study. The researcher as interpretive inquirer interprets events by exploring the experiences of the participants and developing new meaning from interacting with the participants about those experiences. For example, a teacher may let students choose partners for a learning activity. Through conversation with the teacher, the researcher may gain a deepened understanding as to why the teacher designed the learning activity to include partner work. Understanding is an outcome of interaction with the participants.

Ellis (1998) points out that it is important in an interpretive inquiry to begin with an entry question. In this study the entry question was: What are teacher experiences with the Zoology Zone multimedia resource? As teachers engaged in the use of the multimedia resource, many answers and interpretations were possible. Finding the path in interpretive inquiry begins with the entry question and then one makes the path by walking it (Ellis, 1998).

"One must start with openness, humility, and genuine engagement" (Ellis, 1998, p.18). The researcher should never begin by first getting a method wholly determined in advance of an engagement with what it is one is investigating. Instead, research can be described as a conversation out of which new

understanding emerges (Glesne & Peshkin, 1992). This perspective assured me that I might enter the research with possibilities to change how I studied it as I progressed through the experience.

In tracking the progress of an interpretive study it is helpful to visualize the process as a series of loops in a spiral (Ellis, 1998).

> When a study is viewed as a series of loops in a spiral, each loop represents a different attempt to get closer to what one hopes to understand. One enters each loop, or separate inquiry, with a question. What one learns in the loop provides direction or a reframing of the question for the next loop. What one learns may in fact change the direction of the study quite dramatically. (Ellis, 1998, p. 20)

In this study each time the participants met in the group interviews, new ideas emerged in the discussions. In several instances the teachers took the ideas and implemented them in their teaching, thereby changing their experiences with the multimedia resource. Information that was 'uncovered' in the group interview influenced what would occur in the next set of teacher experiences.

Ellis (1998) notes that self-conscious reflection by the interpretive inquirer is the thread that holds the research story together. It is important for the researcher to be aware of pre-understandings that may influence the movement of the study. In the later stages of this study, I discovered that the teacher participants and I had made assumptions about the use of the term SLEs. My reflection on this finding in the study altered the study significantly. By interviewing the participants an additional time, I uncovered a new interpretation of their experiences that altered the interpretation of findings in the study.

Generic Qualitative Research

There are different types of qualitative research. Some forms are more common in educational research, and, according to Merriam (1998), the term 'generic qualitative research' is used to describe the most common form of research used in education studies. In a generic qualitative study, researchers

> seek to discover and understand a phenomenon, a process, or the perspectives and worldviews of the people involved. Data are collected through interviews, observations, or document analysis.

> Findings are a mix of description and analysis – an analysis that uses concepts from the theoretical framework of the study. The analysis usually results in the identification of recurring patterns (in the form of categories, factors, variables, themes) that cut through the data or in the delineation of a process. (Merriam, 1998, p. 11)

The design of this research study is consistent with the characteristics Merriam (1998) has identified as indicators of a generic qualitative study.

Brief Overview of the Research Study

The aim of my interpretive inquiry was to explore teacher experiences with the Zoology Zone multimedia resource in the elementary science classroom. As an outcome of my conversations and interactions with teacher participants in the study, I developed a deepened understanding about the research questions. In this study teachers examined their beliefs and practice, talked with each other, and shared stories from their science classroom experiences of using the Zoology Zone multimedia resource. Through their stories, I created new understandings, deepened my awareness, and transformed my understanding about the use of multimedia technology in elementary science classrooms.

In all activities with the teachers in the study, I tried to be engaged in the research process with them and to be open to what they shared with me regarding their experiences. The research from the literature review informed the study and assisted me in my development of an understanding about the teacher experiences with the multimedia resource. It was my responsibility to reconstruct teacher experiences with multimedia and to derive meaning about multimedia technology and science teaching as a result of exploration of the teacher experiences. The context of my own experiences and perspectives, and the knowledge I gained from the review of the research literature were part of the discovery process and provided contributions to the study.

My role as interpretive inquirer entailed working as a *bricoleur* (Denzin and Lincoln, 2000). I drew upon a variety of methods and assembled the information into a set of representations that connected the findings in the study. Through an interactive process, I took the narratives of the teacher participants and shaped

an interpretation of their experiences. My personal history, biography and views also shaped this process.

In this research project, the interpretations each teacher brought to the discussion assisted in creating new opportunities for understanding and contributed to keeping the conversation alive as the participants journeyed with me in a discovery of multimedia experiences in the science classroom.

The project began with teachers using the multimedia resource in their science lessons and addressing what they were doing in the classroom and why they were doing certain things. Through discussion teachers began to uncover new information about their teaching which enabled them and me to understand the problem differently. From the discussions, new questions were generated.

In my research study, each conversation and meeting with teachers about their experiences with the multimedia resource provided new uncoverings and subsequently altered the course of the research. As the study progressed and teachers shared their experiences, there were new developments that contributed to a better understanding of teaching with a multimedia resource by all the participants in the study (e.g., Leslie began using the question of the day approach after hearing about Suzanne's success with this teaching strategy).

In designing this research study, I identified a set of questions that guided the inquiry. I selected interviewing as the primary data collection method for my study. I also utilized classroom observation and collected some documentation from teacher participants to supplement findings from interviews and observations.

Data Collection

Data Sources

Data was collected through individual interviews, group interviews and visits to the classrooms of each teacher participant. Information that was shared in the interviews with participants enriched contributions from various documents and artifacts supplied by the teachers. These documents and artifacts included student work samples and teacher planning documents. These items assisted

me in better understanding and interpreting the data collected during the interviews and classroom visits.

The primary source of data was individual and group interviews. However, data was also collected through a variety of other sources. The sources of data are listed below. The contribution to the study of each data source is also indicated.

1. Participant survey: This six question survey was completed by teachers considering participation in the project. I used the personal information in the survey to select four participants who might bring different experiences to the research project.
2. Individual interviews: I met with each teacher at least three times for a personal interview. One interview was audio-taped and the transcripts were typed and forwarded to the participant for changes and feedback. I took interview notes during the second and third interviews. I used the data from the individual interviews to develop profiles of each teacher and to describe the experiences of each teacher.
3. Group interviews: Three out of four (the exception being the orientation interview) of the interviews were audio-taped and then transcripts were developed and then circulated to participants. Information from these transcripts was used to identify quotes from the teachers that pointed to an understanding of their experiences.
4. Reflection sheets: In the second and third group interviews, teachers completed a personal reflection sheet. The feedback on the sheet was used to guide group discussions. I was able to use the information on each reflection sheet to identify individual teachers' perceptions and responses to the questions posed about their recent experiences with the CD-ROMs in their classrooms. Not all the information on the reflection sheets was shared in the group discussion so the reflection sheets gave me some additional data on each teacher's experience.
5. Research journal: I started the project with a personal journal where I wrote about my activities and reflected on each activity. The process, which was meaningful in the first two weeks of the project, became too time consuming to complete. Gradually each entry was briefer and by week three my journal was limited to a chronology of events kept

in a desk calendar. Dates and times of meetings, records of telephone calls and timelines provided a chronology of the research project and helped me with management of the study. I used this information to chart the history of activities in the project and the information from the journal formed the Research Timeline (see Appendix P).

6. Field notes: Each time I met with a teacher, visited a classroom or spoke with the participants on the telephone I made summary notes of what I heard, what I saw and suggestions regarding the implications of the event. These notes provided a check on the interview transcripts and provided one more interpretation of the events I was studying.
7. Telephone calls and email correspondence: I used both the telephone and email to follow up with participants on items discussed, status of each teacher in the use of the multimedia resource, upcoming meetings, and for general communication. I entered the participant names as well as the research assistant, on a list serve. Every few days I sent an item of information to participants. I printed many of the email correspondence items in the event I needed to confirm dates or details about proceedings. I also felt that by keeping regular communication with the participants the research action in the schools would continue to move along.
8. Research assistant: I met with the research assistant twice before the project started. At the first meeting I gave her the research proposal to acquaint her with the dimensions of the study. At the second meeting we confirmed her role as a listener and recorder and as my assistant in de-briefing following group meetings. Near the end of the project, we met one evening to review the data collected to date and prepare for the final group meeting. Immediately prior to the final group meeting, we met again. I did not keep notes on these meetings but rather adjusted my plans for upcoming meetings with the participants as an outcome of our discussions.
9. Teacher planning documents: Teachers provided me with a variety of lesson plans, unit plans and personal notes they had made regarding planning. I referred to these to contribute to my understanding of their teaching of the Animal Life Cycle topic.
10. Student work samples: All teachers forwarded samples of student work. These were used to assist me in

understanding what students did in the Animal Life Cycle topic.

Interviews

The purpose of the interviews was to acquire information about each teacher's experience with the use of the Zoology Zone multimedia resource in the teaching of the Animal Life Cycle topic. Interviewing as a research tool includes a wide variety of forms, and is a powerful way in which researchers try to understand fellow human beings. However, the task is harder than it may seem at first (Fontana & Frey, 2000).

Individual and group interviews were used in this study. The purpose, structure and overview of these interviews is described more fully later in this chapter. The interviews were semi structured. I determined before each interview the research questions that I wanted to address in the interview. When the interviews began, I utilized questions to direct the interview to obtain teacher responses on the information items I had identified. However, when the participants proceeded to discuss items that I had not anticipated, I encouraged the discussion to continue if the content of the interview appeared to be useful to my overall understanding of the research problem.

Group interviews can be used to successfully aid respondents' recall of specific events or to stimulate embellished descriptions of events or experiences shared by members of a group (Fontana & Frey, 2000). In this study all four teachers carried out the activity of using the Zoology Zone multimedia resource. The group interview provided an opportunity for teachers to share the different ways in which each teacher experienced the task.

Fontana and Frey (2000) present the interview as negotiated text. They explain that there is a growing realization that interviewers are active participants in interactions with respondents, and interviews are seen as negotiated accomplishments of both interviewers and respondents that are shaped by the contexts and situations in which they take place. The interviewer and respondent jointly construct the meanings of questions and responses. In the fourth group interview in this study, I presented my findings to date, and the participants

provided me with their feedback. Resulting was a negotiated understanding of the text I presented to them. This was also evident in the final individual interviews when participants read my interpretations of their experiences and worked with me to arrive at a negotiated understanding of their experiences.

Carson (1986) suggests that, as co-participants in conversation with researchers, practitioners gain new vantage points on their practice. Carson explains that the practice of conducting conversations with participants is in itself a form of action, which helps forge a reformed practice. By engaging in conversation, researchers are helping to create spaces within educational institutions for thoughtful reflection oriented towards improving practice. In my study, I participated in the discussions and the contributions of all participants informed the study and pointed to implications for teaching practice.

Trustworthiness of Data

It is important in a research study that the method provides authentic, valid and reliable findings. In educational research there are a number of strategies that are useful when addressing the problem of validity (Bogdan & Biklen, 1998). I utilized triangulation of data (Fontana & Frey, 2000), attention to development of rapport (Fontanta & Frey, 2000, Glesne & Peshkin, 1992), member checks, and revisiting the data to gain a broad interpretation of the data.

Triangulation (Fontana and Frey, 2000) allowed me supplement findings from classroom observations with findings from the individual and group interviews. Review of data from a variety of sources assisted in providing a more complete picture of the individual and group experiences.

I wanted to establish a rapport with participants that would demonstrate my interest in their contributions to my research study and would encourage them to contribute meaningfully to the study. Glesne and Peshkin (1992) report that rapport is tantamount to trust, and trust is the foundation for acquiring the fullest, most accurate disclosure a respondent is able to make. I planned for this strategy by providing comfortable settings for meetings, serving refreshments and taking an opportunity to chat with participants about other events unrelated

to the study. I also utilized a research assistant to monitor my actions and provide me with feedback regarding my participation in the group interviews. I discussed with the research assistant my goal to be a good listener and to facilitate interviews in a manner in which all participants had opportunity to contribute. Debriefing with the research assistant after each interview assisted me in continuing to ensure positive rapport in future interviews.

The transcripts of the audio-taped individual interviews and the group interviews were shared with the participants. Their interpretation of the data was important in validation of the data. Krawthwohl (1998) suggests that this process of directing the data and analysis back to the respondents, known as member checks, contributes to the validity of the research process. The findings were also shared with the research assistant. As an observer in the individual and group interviews, she provided an additional viewpoint on my interpretation of the findings.

Revisiting the data assisted me in better understanding the data. Following each step in the research process, I made notes on emerging findings. Then, I left the data for a week or more before revisiting it. This allowed me to examine the data from a fresh perspective. By approaching the data at different intervals, I had time to reflect on my first findings and to formulate new interpretations. I found that, by detaching myself from the information for a period of time, I developed a richer interpretation of the data.

Limitations

Outside or external forces may have influenced the study are as follows:

1. Teacher honesty and cooperation: I relied on honest sharing as part of the individual and group interviews.
2. Technical considerations: Success of the study was dependent on teacher participants being able to use the multimedia resource in science classrooms. Appropriate hardware and technical support to run the multimedia software was critical to the study.
3. Memory of teacher participants: I relied on teacher recall of experiences in the classroom.

Ethical Considerations

This research was conducted in accordance with the University Standards for Protection of Human Research Participants that have been established by the University of Alberta. Participation in the study was voluntary. All participants were informed in writing of the nature, the purpose and the significance of the study. They were made aware of their right to withhold information and to withdraw from the study at any time. Confidentiality of all participants was assured throughout the entire study. Anonymity of participants was protected as much as possible and pseudonyms have been used when it was necessary to identify specific participants. All participants were invited to review and amend all transcripts of interviews, draft copies of chapters four, five, six and seven of the manuscript, and audiotapes prior to publication.

Data Analysis

My interpretation of the data from this research study involved an examination of individual stories of each of four participants as well as the collective story shared when the research group convened and shared experiences. The collective story reflected the understandings of individual members of the group. The findings, as told through my subjective lens, are illustrated with the words of the participants as they shared personal experiences.

> Our texts must always return to and reflect the words persons speak as they attempt to give meaning and shape to the lives they lead. The materials of the biographical method resolved, in the final analysis, into the stories persons tell one another. (Denzin, 1989, p. 81)

The first individual interviews and the second and third group interviews were transcribed from the audio-taped accounts of the interviews. My next task was to analyze and code the information in a manner that would assist me in describing the experiences of the teacher participants. The first step involved listening to each audiotape and then reading and re-reading each transcript to familiarize me with both the content and the tone of the interviews. Silverman (2000) states that the tapes and transcripts of interviews capture the actual

happenings and detail of the events being studied and are a logical place to begin analyses. The tapes and transcripts also offer a public record of the events. The record can be listened to repeatedly for different interpretations and the transcripts can be reviewed, improved, and may point to other findings in the study (Silverman, 2000).

Silverman (2000) refers to the text in interviews as conversation and provides researchers with three simple rules to carry out conversation analysis which I found useful in examining data collected from both individual and group interviews:

1. Always try to identify sequences of related talk.
2. Try to examine how speakers take on certain roles or identities through their talk.
3. Look for particular outcomes in the talk and work backward to trace the trajectory through which a particular outcome was produced. (Silverman, 2000, p. 831)

These rules were applied to my analyses of data. In my attempt to make sense out of the conversations, I examined each transcript and highlighted keywords and segments of conversation that pointed to things that the teachers did, or that the students did during the use of the Zoology Zone multimedia resource. Then, I highlighted conversation segments in which teachers said things that pointed to how they felt about the multimedia resource. I limited my highlighting to events, or parts of events, in the conversations that were directly linked with the use of the Zoology Zone multimedia resource. For example, there were interesting points volunteered by teachers about class size and inequalities in schools on matters of pupil teacher ratio. These tangents in conversation were not included in the coding process. I searched for particular outcomes or patterns that teachers volunteered about their experiences with the multimedia resource. For example, one teacher stated that readability was the strongest feature of the multimedia resource and other teachers indicated agreement for this statement. Then, I traced back through the transcripts to

identify other indicators from all participants that linked to the concept of readability that had been identified as an outcome of the experience with the multimedia resource.

The coding process involved the identification of many descriptors of teacher experiences with the multimedia resource. I looked for common categories in the descriptors and began grouping related descriptors under categories. For example, the category of technical concerns included many descriptors volunteered from the four participants including: access to computer labs, computer memory problems, copyright issues, log off problems, incompatibility with other school software, sound concerns, and computer projection problems.

As the descriptors were coded and organized into categories, I examined the findings to see if a pattern emerged. At this point in my analysis, I was searching for patterns that might help me in organizing my findings. My search for patterns began after the second group meeting when participants shared their experiences with the initial use of the Zoology Zone multimedia resource. I attempted to group the data generated from the group meeting into clusters of related findings. Resulting was a lengthy list of categories. In the second and third individual interviews with each participant I encouraged feedback on the categories I initially identified. My second attempt at clustering data occurred in the preparation activities for the final group interview. After reviewing all data from all sources I coded participant feedback and reduced the categories to what I initially identified as seven general patterns, which I initially termed 'themes.' During the data analysis phase of the project I reorganized and renamed the themes into 'categories.' The categories, which were discussed with the participants at the final group meeting included: (1) multimedia benefits, (2) teacher role, (3) technical support, (4) beliefs about student learning, (5) classroom management and multimedia, (6) special needs, and (7) teacher learning. During the final group meeting I encouraged interpretation from the participants of the findings I presented using a data display chart.

The final development of categories followed many attempts to reorganize the data in meaningful patterns that contained the understandings of all participants. I reviewed the data again and grouped the data into categories that were common to all four participants. The resulting clusters of data were identified as four general categories which allowed me to examine the contributions of each participant in relation to each category. The findings from the study are grouped into four categories and are discussed in Chapter Five.

Miles and Huberman (1994) suggest that the creation of visual displays allows researchers various strategies to identify patterns within the data. In my data, key words and phrases taken from the transcripts of the interviews directed me in uncovering initial clusters of findings that were related. I listed these findings under main headings and provided a chart which I shared with the participants during the fourth group interview. After seeing and hearing my perspective, the research participants provided feedback to me on the findings I had identified. The visual display of the findings served as a guide in the discussion with participants and assisted conversation that clarified and added to the data collected.

The participants had three opportunities to give me additional feedback on my written accounts of their experiences in the research project. They received transcripts at the beginning of the fourth interview. Then they were forwarded the first drafts of the findings and conclusions a few weeks following completion of the teaching of the science unit. Four months later they were given opportunity to review the description, discussion of findings and implications for the project. Their input assisted me in improving my description of their experiences. They made changes to portions of the transcripts and offered clarification on some of the text that was presented to them.

The third individual interview with participants took place four months after the teachers had used the Zoology Zone multimedia resource in their classes. During these interviews I sought to solve a puzzle that emerged in my analyses of data. All four teacher participants used the term SLEs many times in their descriptions of their experiences with the multimedia resource. In my

interpretation of the data, there was a some confusion and omissions regarding the findings related to 'student learner expectations.' To solve the puzzle, I met again with each participant and shared findings to date and presented the questions I had regarding my findings. During these interviews I found that the four participants were using the term, SLE, in a manner that was inconsistent with the intended use of the term in the elementary science program. Consequently, despite the accuracy of the transcripts, the interpretation of the words used by the teacher's in conversation was more important than the words themselves. Silverman (2000) discusses this scenario as a puzzle that the researcher must address by working back and forth in the data to seek a solution to the puzzle. In this study, the solution was uncovered in final individual interviews with teacher participants.

The Story of Conducting the Study

Background to the Study

In early spring of 2000, I was excited about the status of the production of the Zoology Zone multimedia resource partnership project that had been evolving for five years. Two of the three CD-ROMs in the trio of resources were completed. The two completed CD-ROMs would have additional special significance for me as they would be used in my research project. I spent time thinking about the manner in which teachers would use the multimedia resource. I paid particular attention to quality control issues with the software and anticipated problems and challenges that teachers might find in using multimedia. I thought about the role of the multimedia resource in my research project and wrestled with questions on how I would proceed with my research plan: "Would the software work in the schools I selected as research sites?" "Would teachers have the technical support in their schools that they required in order to ensure implementation?" I had moments of doubt: "Who would the research participants be? Would any step forth to volunteer?" And finally, "Would the five years of collaborative work with the Zoology Zone multimedia resource project result in meaningful findings in my research project?" I decided

that it would be helpful to have a well thought out plan prior to selection of the participants for the project to encourage teacher volunteers who would provide meaningful input to the research project.

Preliminary Plans for School Involvement

I wanted to do what I could to secure teacher volunteers who would be committed to work with me for at least three months and would enjoy and benefit from involvement in the study. It was also important that participants would have the support of their school administration for technical support and access to computer labs if problems arose in these areas. I also wanted to prepare adequately so that potential participants would have a general awareness of what the project involved and would be prepared to work with me in a climate that was mutually beneficial to me and the teacher participants. I wanted teachers who would be confident to speak out about the project dimensions and would feel comfortable in both individual and group settings. In order to try to meet my objectives for participant selection, I developed a three step plan which I implemented in the spring: (a) approval processes, (b) research study awareness, and (c) promotion for study.

The approval process began when I approached school administrators in three school districts in mid April, by telephone or in person, and inquired about possible interest in school participation. I provided a brief summary of the Zoology Zone multimedia software and informed administrators of the need to have adequate technology in the school to operate the software. Initially all three school districts expressed a desire to participate. I asked the administrators to consider the possibility of involvement and indicated I would get back to them later in the month. One district indicated that it would not be convenient to be involved due to limited availability of the required hardware accessible to grade three students. The remaining two districts, one being the district where I am employed, continued to be interested in involvement. I talked to the superintendents of both interested school districts and was given verbal approval to continue with my proposal to find participants. The superintendent of the

district I was not in invited me to work with the two school district office elementary 'helping teachers' who worked closely with all district elementary teachers on curriculum implementation. The superintendent offered further support by speaking with the two helping teachers and encouraging them to work with me on finding possible teacher participants. This school district had Macintosh computers in all elementary schools and for purposes of discussion in this study will be referred to as the MAC based school district.

The second step was to share an awareness of the research project with potential participants. I felt that the more information I could share on both the multimedia software and involvement in the research project, the greater my chances would be of attracting suitable teacher participants. I developed an information package, which included a summary of the Zoology Zone multimedia resource and made available test copies of the CD-ROMs for possible interested administrators. I presented this information at the administrators meeting in my home school district and requested that the project opportunity be advertised in elementary classrooms. There were many schools expressing an initial interest to be involved. Next, I spent one morning meeting with the two helping teachers in the MAC based school district. I shared suggestions about use of the resource and demonstrated both the Spider and Bear CD-ROMs. We discussed many possibilities for use of the multimedia resource in elementary schools and reviewed the dimensions of my proposed research study. Both teachers brainstormed possible school sites and potential teacher participants who would best fit the criteria I outlined in my overview of the project. The helping teachers were enthusiastic to have teachers from their district be involved in the project. They assured me that they would take the proposal to the district administration group and then would forward information packets to all elementary schools, follow up with reminders and approach some of the teachers they anticipated would benefit from involvement in the process. I left sample copies of the software for the helping teachers to bring to district schools and assured that if there were questions about the research project or the software to contact me.

The very enthusiastic response and commitment by the school district to carry out follow up to find suitable teacher volunteers were most encouraging.

In early May the three partners in the Zoology Zone multimedia resource project selected a date to carry out a media launch of the completed bear and spider resource. I volunteered to chair the committee and received the support of the partners to use the event to promote teacher involvement in my research project. There was agreement to provide me with sufficient complimentary copies of the software to distribute to teachers attending the launching. I also received support to guarantee that I would have sufficient copies of required software available to me in the early fall to carry out the research project. I was encouraged by the support of the project partners for my research project.

The media launching, set for late June, was an important benchmark in my project. The event would feature public promotion of both the Zoology Zone multimedia resource software and my research project. I needed to ensure that there were many teacher participants in attendance at the launching. I drafted invitations to the launching and included product information about the resource. Every elementary school principal in the city and surrounding area received an invitation. In addition, I wrote a specific letter of invitation to all grade three teachers in the two school districts (see Appendix D). I explained that I was seeking teachers with a variety of experiences in both technology and science. I advertised that complimentary software would be available. I wanted to attract teachers with varying backgrounds and experience and I was aware that elementary teachers are eager to obtain complimentary teaching resources and that the lure of free software might bring more teachers to the launching. Included with the letters to grade three teachers was a two-page survey that I asked them to complete and bring with them to the launching if they were considering being one of the research participants. The survey included questions that would assist me in identifying individuals who best fit the criteria I had developed for involvement in the project (see Appendix E). I carried out several follow up telephone calls to the helping teachers to provide reminders

and encouragement to teachers in the MAC based school district to attend the launching. I was delighted with the list of positive replies to attend the launching.

The evening of the launching was the key event in promotion for participants for my research project. I had additional copies of information packages for teacher hosts to give to grade three teachers as they arrived. The names of grade three teachers were added to the possible participant list and they were given surveys and invitations to participate in the research project if they had not previously received copies. I made a conscious effort to welcome grade three teachers to the event and asked them to see me at the conclusion of the evening if they had questions about involvement in the research project. As master of ceremonies for the event, I introduced the research project and extended an invitation to the guests to consider teachers who may be interested in the research project. I indicated that the research participants would be selected within a few days of the launching. I explained that I was seeking teachers with little or no experience in science and technology as well as teachers with considerable experience in these areas. The launching was a success and every grade three teacher in attendance received at least one copy of the software. By the end of the evening I was encouraged by many comments from teachers who said they were enthused about the multimedia resource and were considering participation in the research study.

Selection of Participants

The participant survey provided information to help me in selecting which teacher volunteers I would select for participation in the project. My intent was to select four teacher participants who would be teaching grade three science the following school year and had varying levels of training or experience with grade three science, had a range of skills, abilities and attitudes regarding technology, and had teaching styles that were different from each other.

The first four questions on the survey inquired about formal education and professional development in science teaching, teacher attitudes about science teaching, technology integration in the classroom, and classroom climate and

teaching style. The fifth and sixth question asked about teacher planning and assessment.

There was generous space to allow for 'other' responses. The four selected participants did volunteer additional information to clarify or extend on the responses provided in the survey.

Over 30 surveys were distributed to grade three teachers. Eleven were returned to me. Of the teachers interested, two did not have assignments in grade three the upcoming year and one did not have the hardware in the home school to operate the software. Of the eight remaining volunteers, I reviewed all responses on the survey and thought about the best combination of teachers to ensure a group of four participants who would work well together and would be useful in generating data on my research problem. All volunteers were from two school districts. One school district was MAC based and the other district was PC based. Aware that the Zoology Zone multimedia resource software was initially designed for Macintosh computers and that in the pilot phase there had been considerably more technical problems in classrooms that had PC computers, I decided I might have greater technical success in the MAC school environment. A second reason I decided not to utilize participants from the PC based district was that I was an employee of that district. I felt that my position as a school principal might possibly affect participation of fellow employees. By selecting all four participants from a district with which I was not familiar, I avoided any problems that could be linked to my authority as a school administrator.

After reviewing the remaining six possible participants, I focussed on finding a group of four teachers who had different backgrounds and experience and attitudes about teaching science and using technology. I also considered the factor of representation from schools in different communities in the city. One of the applicants lacked skills and confidence in matters of computer technology. I selected her as the teacher with the least experience in technology. On the opposite end of the continuum for technology integration was the second chosen candidate. She had considerable experience, interest and skills in both science

and technology, was highly recommended by the helping teachers, and had been on various school district technology and science curriculum committees. The two remaining candidates would be situated midpoint on the continuum of technology integration. All four teachers had at least ten years of experience and all reported that they enjoyed teaching science. I did not receive any applications from relatively new teachers to the profession. The four teachers selected represented four different schools, two in more economically advantaged communities, one in an average socio-economic community, and one drawing students from a community of considerable poverty. The teaching styles of the four participants varied between highly structured approaches to considerably less structured and moderate student directed learning in science.

Notification of Participants

At the end of June I contacted the four participants by telephone and invited them to be participants in the research project. They all expressed a willingness to be part of the project and were happy that they had been selected as participants. I indicated that I would deliver additional information to their homes in early July including consent forms for participation. I notified the school district superintendent of the names of the participants. In the first three weeks of July, I visited the home of each participant and provided additional complimentary copies of the software for use over the summer. I chose to personally deliver the items as I felt the personal contact would be a positive way to begin developing a relationship with the individual teachers and would communicate my support for them as participants in a project that was very important to me. Included with the software was a copy of the Zoology Zone multimedia resource teacher guide, a letter of invitation to participate in the project (see Appendix F) a consent permission form (see Appendix G), and an invitation to join me for the first group supper meeting at the end of the August. I forwarded a letter to the school superintendent requesting permission (see Appendix H) to carry out the research in four schools and within a few days received a letter of permission to proceed. In mid August I approached a teacher

colleague to be my research assistant and she accepted the invitation to be involved. Her role would be to take notes during group meetings and to de-brief with me following the group meetings on both the content of the group discussions and on my role as group facilitator. In late August I telephoned all four participants and reminded them of the first group meeting.

First Group Meeting: Orientation Phase

The first meeting as a group was a supper meeting. One of my goals was to have all members of the research team to socialize and begin developing what I hoped would evolve into a positive professional relationship. I wanted the climate to be positive to encourage the participants to be enthusiastic about their involvement as participants in the research project. This meeting marked the beginning of rapport and friendship that would continue to develop over the next three months.

I wanted the participants to leave the meeting aware of my role as researcher and familiar with the dimensions of their involvement in the project. I prepared an agenda (see Appendix I), a calendar, and brought numerous samples of support documentation including the Elementary Science Program of Study, the Zoology Zone multimedia resource teacher guide, and the Information, Communication and Technology program of studies. The information was available for them if they decided they wanted to use it to assist them in carrying out their role in the project. It was important to me that they viewed me as a resource person who could assist them if they ran into questions or challenges while participating in the project. I also wanted them to be clear on their role as peer supporters and that part of the project success would be determined by what they learned from each other and me by the end of the project. I wanted them to become acquainted with each other and with me and to begin to appreciate the unique attributes of each other as co-participants in the research. Since all participants would be working together using the same teaching resource there would be benefits if all participants had a basic understanding of each other. Kemmis and McTaggert (1988) write about the importance of

participants in action research groups to engage in a 'reconnaissance' phase before commencing the research process. Reconnaissance provides participants opportunity to talk about their present situation, identify their values about teaching and learning, think about how their work will fit into the larger context of schooling, and construct an understanding of their own past experiences as educators in relation to the research context. Although my project is not specifically action research, the components of group sharing have similarities to action research and the message of reconnaissance has significance. Carr and Kemmis (1986) state that "educational activities cannot be observed without reference to the shared educational values and beliefs of those engaged in educational pursuits" (p. 111). Because the four participants would be working in a group, I felt we needed to find out about each other's values and beliefs about teaching and learning, science, and technology. The first group meeting provided opportunities to develop this understanding of each other. This first group meeting was not audio-tape recorded because of the focus on orientation, socialization and developing a start to a new relationship.

Individual Interviews

There were two main purposes to the first personal interview that I had with each participant. Firstly, I wanted to gain a better understanding of them as teachers. I wanted to learn about how they taught. Secondly, I wanted to explore their experiences with technology integration and what views they held about multimedia and science learning. I arranged to audio-tape record these interviews in the homeroom classroom of the teacher. I have found as a supervisor of teacher instruction that a great deal can be learned by being in the classroom setting of teacher. The climate, décor in the classroom, arrangement of furniture and presence of resources all assist in the formation of perceptions about the teacher professional. I wrote down some possible questions to guide the interview but for the most part I wanted to keep the conversation as open ended as possible (see Appendix J). Open ended interviews elicit more extended and valuable responses from participants than highly structured

interview protocols (Biddle & Anderson, 1986). The initial interviews with each of the four participants provided me with information pertaining to their previous training and experiences, their professional backgrounds, educational values about science and technology, and helped to anchor my perceptions about them in the climate in which they worked. I took brief notes during the interview and audio-tape recorded each interview. The interviews were held at the end of the school day. I found the teachers to be quite tired and experienced several interruptions in the course of each interview. The schools were very busy at the close of the day with a variety of interruptions that punctuated the interviews. Intercom announcements, telephone calls, and students, parents and staff popping in the classroom all interrupted the interview. The teachers continued with the interview but I made the decision that I would hold the group interviews at a site where I could have some control over limiting the number of distractions.

Following the first interview with Roberta, I discovered that although the tape had been advancing in the recorder there were many sections that were blank. In places on the tape, there were also two portions of the interview that were overlapped causing a recording that was impossible to transcribe. At the close of the research project, I met with Roberta and we attempted to edit the brief transcript of the interview and reconstruct the contents of the interview based on the notes I had taken during the interview and Roberta's recollection of the interview.

I met with each participant individually a second time. These interviews were held in a variety of settings: Suzanne in her classroom, Leslie in the school staff room, Heather in her classroom, and Roberta in a neighbourhood coffee shop. I did not audio-tape record these interviews but had a series of questions that assisted me in the interview process. I was seeking specific information on the research questions for the project. Initially I felt that I might acquire more information if I did not audio-tape record the interview. The notes from these interviews provided me with generous information in determining themes emerging from the study and assisted in giving me direction for planning for the final group interview. In retrospect, I think taping these interviews would have

been beneficial because of the depth of information the teachers provided. However, if I had audio-taped the interviews, I wondered if the teachers would have shared the same information.

Four months following the fourth group interview I arranged one final individual interview with the participants. This interview was not initially part of the research plan. However, when I completed an analysis of the data, there were puzzles I uncovered in the data that I felt would be most accurately addressed by further conversation with the participants. These interviews proved very useful in assisting me in understanding the data I had collected. Questions for these interviews centered on the transcripts from the previous individual and group interviews. I invited participants to clarify their understanding of the Alberta Elementary Science Program of Studies as it related to this research project. I took notes during these interviews and also provided each participant with a summary of my description of their experiences in the research project. I also provided participants with handouts highlighting the Alberta Learning expectations for the teaching of grade three science and the teaching of the ICT outcomes. The teacher participants used these handouts to clarify their experiences with the teaching of the Animal Life Cycle topic. They also elaborated on their experiences with the Zoology Zone multimedia resource and volunteered opinions about technology and science teaching. They were enthusiastic about helping me capture and understand their experiences during the research project.

Classroom Visits

I visited the participating teachers at least twice when they were teaching their homeroom students. I wanted to see the teachers working with their students to give me a better understanding of teaching style. I also wanted to get a sense of the student population in each classroom and the climate for learning. These visits to the classroom were enjoyable. I was welcomed by teacher and students and was pleased with how co-operative and open the students were with me during my visits. They volunteered questions about the research project

and happily provided answers to questions that I asked about things they were doing in class, how they felt about different activities in the Zoology Zone multimedia resource and other items of spontaneous discussion that they initiated. I observed each class at least once in the school computer lab working on science lessons. I also observed students and the teacher at least once in the homeroom classroom. I took field notes on these visits and jotted down questions that came to me about the visit. At subsequent meetings I spoke with the teachers about my findings during the classroom visits and my questions from the visits. I brought models of spiders and other support resources with me on the classroom visits and several of the students took interest in looking at the models and other support resources I had in my resource box.

Second and Third Group Interviews

The first group interview was focussed on orientation to the project. The second and third group interviews were designed to obtain data on progress with the use of the multimedia resource in the science classrooms. Both the second and third group meeting were facilitated in a similar manner (see Appendix K and L).

Both interviews took place in my office around a large table that comfortably seated the four teacher participants, the research assistant and me. I instructed the secretarial staff to limit interruptions during our group meeting. The meetings were held at 4:00 p.m. to allow teachers sufficient time to get from four different areas of the city to the meeting place. I supplied snack items and encouraged teachers to socialize and enjoy refreshments and each others' company before beginning the group interview. The interviews were audio-tape recorded. Prior to both meetings, I shared the agenda with the research assistant and we briefly discussed her role as note taker and advisor to me during the interview process. She was also the audio-tape recorder technician taking responsibility to watch the tape and adjust controls, change the tape or alert me if there were problems with recording.

After sharing the agenda with the teachers, and reviewing a few information items, each teacher was given a reflection sheet to complete (see Appendix M). I allocated approximately ten minutes to have teachers enjoy snacks, and think back on the previous weeks of teaching and their experiences with the multimedia resource. They were encouraged to jot down their responses to a few guiding questions regarding their use of the multimedia resource in the lessons preceding the group interview. The intent of the reflection sheets was to give some personal time for reflection prior to sharing with the large group. The reflection sheet questions would serve as a guide for a portion of the group interview.

During the second group interview, I reviewed a process for the group discussion. Some guidelines for contribution were reviewed including my request to hear from all participants and that all contributions were valid and encouraged. An order for contributing was determined. I wanted to ensure that all participants were given equal opportunity to talk. As the interview progressed participants were encouraged to contribute to the discussion by seeking clarification, asking questions or adding personal experiences to the discussion. Participants had been reminded to bring any items for sharing including lesson plans, student assignments and supplementary resources. As part of the group discussion they shared the items they had brought with them. I interjected with questions I had to clarify discussion items and to bring in additional questions that moved the discussion to address some of the research questions in the project. The third meeting progressed similarly to the second meeting with the exception that I presented clarification on the differences between different types of computer technology and the specifics of multimedia in the repertoire of computer technology. Now that participants were familiar with the Zoology Zone multimedia resource materials, it was important to me that they understood that the focus of future meetings and discussions would be on multimedia and science education. At this meeting the Bear CD-ROM was distributed to all four teachers and they were given time to discuss different approaches they might be considering in the use of the Bear CD-ROM.

Fourth Group Interview: Summation

One purpose of the fourth group meeting was to have teachers share their experiences with the multimedia resource since our last group meeting, one month earlier. In the time between meetings all teachers completed the spider unit and were either finished (Suzanne or Leslie) or had one or two classes left to close the bear unit (Roberta and Heather). Part of the fourth group interview would address their experiences as we had done in the second and third group interviews. A second purpose was to have teachers review the research project and hear me present findings that I had uncovered from the data collection. Since this would be the last meeting as a group, I wanted to have all four participants review the research journey and contribute anything they could to the findings I shared with them at the meeting. Their involvement with my project was winding down and all four participants were proceeding with other units of study in their science classes.

This was a critical meeting for additional data collection and for interpretation of some of the data that had already been collected. I wanted to develop a climate for rigorous discussion and at the same time provide participants with an understanding of the journey we enjoyed together for the preceding 10 weeks. I took time to put together an agenda package and to plan meeting activities (see Appendix N) that would facilitate obtaining valuable input from the participants. Unlike the previous group meetings, where participants did most of the talking, I would play an important role in summarizing the research journey and sharing with the teachers findings that I had uncovered in the research process. I presented information on a variety of themes. Following the group interview, the themes were subsequently renamed as categories, which was a more appropriate description of the findings, and clustered into four categories (see Appendix O). These categories provided the framework to organize the findings from the research project. I wanted the fourth group meeting to proceed differently from the previous two meetings so I held the meeting in a spacious meeting room in the school district central offices. I planned carefully and prepared charts, displays and an agenda package so that

the two hours allotted for the meeting would be efficiently utilized. Each teacher received completed copies of all the transcripts of individual interviews and group interviews, a summary of the research problem, research questions and research purpose, a list of participants' motivation to join the project, and an individual participant feedback sheet.

Two days before the meeting all participants received a follow up telephone call and email reminder to attend the meeting. I invited all participants to join me in a complimentary supper following the meeting to celebrate the completion of the Zoology Zone multimediá resource use in their science classes. One hour prior to the meeting, I met with the research assistant and reviewed the models and charts I had displayed in the meeting room. I explained how I planned to use the visual display to guide my explanation and presentation. We discussed each of the themes that I had identified from data collected. We decided that the research assistant would contribute to the discussions if she felt that new themes were being introduced or if there were discussion items put forth that could be added to the existing themes. She would continue to take notes during the audio-taped interview but would listen for clarity as participants talked. Since this was our last group meeting, it was important that the intent of each participant's contributions was interpreted as accurately as possible. She volunteered to address clarity issues if I missed the opportunity to do so.

After snacks and brief socializing we proceeded with the lengthy agenda. The pre agenda item of determining a restaurant for supper took 15 minutes but got everyone motivated to move through the agenda and look forward to opportunities to socialize following the work. By the time we moved to addressing the first agenda item, the somewhat fatigued teachers who entered the meeting were energized and enthusiastic about discussing their experiences.

Part of my presentation included a review of the research journey. This presentation summarized the purpose of the research project and detailed the role of the participants in the study. My intention was to have all participants clear on where their contributions to the project fit in the overall research plan. I also wanted them to know that any additional contributions or feedback that they

could give me in any of the phases of the project would continue to be welcome throughout the next few months when I would be writing about the findings. The four teachers were very attentive during the presentation and offered some excellent questions to clarify understanding of the project by all participants. When the meeting proceeded to sharing the themes I had identified, all four teachers joined in discussion clarifying and extending some points and adding new ideas. At the close of the meeting I was pleased that all items on the agenda had been covered and that the participants had shared generously their thoughts, reflections and experiences. Arrangements were made for me to meet again with individual teachers to pick up transcripts, with amendments and changes at teacher request, and to distribute new transcripts for their review. I also collected the class sets of the Spider and Bear CD-ROMs and delivered a copy of Raptors, a third CD-ROM in the Zoology Zone multimedia resource set that had recently been released. The teacher participants were interested in viewing the new release and sharing it with their students.

Data Management: Storage, Organization and Display

All data was stored in a system of files so that retrieval was convenient. Information about each participant was directed to individual teacher files. Data from the group interviews were reviewed and descriptors of teacher experiences were flagged in the source transcripts. After each interview and classroom visit I reviewed the data and searched for descriptors of teacher experiences and examined the data for emerging patterns. Any data volunteered by individual participants was copied and put in the individual story file of that participant. The complete data was then examined and organized into categories and data that did not fit into any specific category. This process was an attempt to reduce the data into manageable components.

The data was organized around initial themes identified mid way through the research project (after the third group interview). These themes were the first level of analysis and stemmed from the research questions. My perspective was revealed in the identification of the themes which was shared with all

participants during the fourth group interview. I found it helpful to visually display both the research journey and the identification of themes and sub themes to consolidate my understanding of the data and to share these findings with the participants. After studying the data more fully, I determined that the label category was a more appropriate description of the clusters of related descriptors than theme. From that point on in the study, findings were interpreted from the categories and the label theme was removed from further discussion of the research project.

The process for the research project was documented in a research timeline (see Appendix P). It was nine months from the day the research participants were selected until the final individual interview with participants was completed.

Chapter Summary

This generic qualitative research study provided the researcher with a large amount of data about four teachers' experiences with the Zoology Zone multimedia resource. The data collected from individual and group interviews, and classroom visits was organized into categories that reflected the experiences of the teacher participants. As the study progressed the experiences of the teacher participants evolved and the data pointed to findings about teacher use of multimedia science resources in the elementary classroom.

CHAPTER FOUR
DESCRIPTION

Introduction

Each teacher reported a different experience with the use of the Zoology Zone multimedia resource in the Animal Life Cycle topic. The variation in the experiences between the four teacher participants was affected by many factors including the nature of the student population in each class, the availability of resources in each school, and the differences in the personal teaching style of each participant. There were also similarities in the experiences reported by the four teachers. In attempt to highlight these similarities and differences, I have presented the experiences of each teacher under three headings: (a) planning and introduction of unit, (b) teaching and learning activities, (c) assessment, and (d) teacher reflection of experience.

Planning and introduction of the unit addresses activities undertaken by the teacher to begin using the Zoology Zone multimedia resource. The description of these activities includes discussion of teaching activity during the initial phase of the research project, beginning when the teachers received copies of the Spider and Bear CD-ROMs in early July. The description closes with the orientation of students to the Spider CD-ROM in the first lessons in the Animal Life Cycle topic. The section on teaching and learning activities describes the activity in the classroom during the teaching of the spider and bear portions of the Animal Life Cycle topic. Various teaching and learning activities that were planned by the teacher for the major portion of the Animal Life Cycle topic are presented to illustrate the experiences of the four teacher participants in teaching the science unit. In the third section, I share experiences of the teachers on issues of student assessment. In the fourth section, I present the reflections of the teacher participants. At the completion of the teaching of the Animal Life Cycle topic the four teachers provided their input on their use of constructivist pedagogy, and their interpretation of the technology applications of the Zoology Zone multimedia resource in their classrooms.

Teacher Profiles

I begin with a profile of each teacher participant to introduce the teachers, their students, and the climate for technology for science learning in each of the participating

Profile of Heather

Heather has been teaching for many years at the elementary level. For seven years she taught French Immersion kindergarten and grade one and then she moved to English kindergarten. She was in her third year of teaching grade three in the school that she has been at for six years. During the research study, she had many grade three students that she had previously taught in kindergarten.

Heather was a graduate of McGill University with an elementary education degree. Her formal training in science education was limited to the mandatory courses that she had to complete to obtain her degree. She has learned about the science program of studies by being active in school district in services and workshops and from her personal experience in planning science lessons for the past three years. Science was one her favorite subjects to teach and she had a rich supply of resources that she used when teaching. She liked to use hands on approach to science learning. However, because she was not comfortable with having live animals in her classroom, she used alternative activities such as videos and pictures when teaching the Animal Life Cycle topic.

Her training in technology was very limited. She had attended various professional development sessions in her school on technology but stated:

> I find it is challenging to use technology in an effective manner due to limited knowledge and experiences. I don't know a lot about computers and this project will force me to use them. I can use Internet a bit and email and some word processing and that's it.

She believed that students really liked using computers so she wanted to use computers to supplement her other teaching activities. In the previous school year, her students had completed an Internet project on the topic of polar bears as part of a social studies unit. She needed to have several parent helpers

in the classroom to assist students in the computer lab with completion of the project. Her homeroom classroom had one computer that was primarily used by the students as a centre during free time. Often, students assisted other students in using the computer programs and operating the computer. For the most part, Heather did not have a strong understanding of the classroom computer or software that was available on the classroom computer. There was a computer lab in her school and technical support was provided to classroom teachers by the principal and a technology lead teacher. She was aware of the ICT outcomes but recognized that this was a priority area of professional growth for her.

Heather considered her strengths as a teacher to be her organizational skills. She was well prepared in lesson and unit planning and creative in her planning of student activities. During my two visits to Heather's classroom it was apparent that she was very flexible and patient, efficiently co-ordinating students who were completing a variety of activities. Her students were simultaneously working on more than eight different activities in individual, pair and trio groupings. Heather assisted students patiently while charting each student's progress through activities on a checklist.

Heather's beliefs about how teaching and learning included an appreciation for a variety of teaching approaches:

> There is a time and place for quiet and at times I do use direct teaching. But productive noise and movement of students around the room is okay if they are on task. I know that it is okay to let kids go with a good thing and I need to read how they are progressing and am prepared to adjust instruction accordingly.

Heather said that she felt she was becoming increasingly more flexible with providing additional opportunities for student learning as she became more confident and knowledgeable about the grade three curriculum. She said that she worked hard at being as consistent and fair as possible in dealing with her students.

Heather's Classroom

There were 18 students in Heather's class and it was one of the smallest classes she had enjoyed in her career. Students ranged from low average to high average in ability and generally were well behaved. Most of her students came from average socio-economic backgrounds, and most of the students had computers at home. She indicated that a few students might benefit from enrichment activities. There were not any special needs students in her classroom. Heather was pleased with the low student enrolment because she had time to get to each student during most learning activities. Student desks were arranged in pods of two and Heather frequently moved the pairs of desks together for larger cooperative learning activities or separated the desks for activities that were more individual. Walls were covered with posters, student work and other motivational and information items. Heather taught all core subjects to her homeroom class and had at least one class block each week in the computer lab.

Profile of Leslie

Leslie has been teaching for many years at the elementary level and for the past twelve years as been in the same school district. In her seventh year teaching grade three at the same school, she was very familiar with the programs of studies for grade three students. Leslie was very involved in her school. She was an active member of the school technology committee and was a member of various school committees including the school intramural program and various project committees.

She had graduated with a Bachelor of Education in elementary education and had a preference to teach math. She had no formal training at university in science but had developed her teaching skills in this area through regular attendance at school district professional development activities. In the transition from the former elementary science program to the 1996 program, her school district had a science consultant who provided binders of information and led many after school in services, which Leslie attended and found very useful.

> He gave us probably ten times more stuff than we could ever use but at least we got some good direction, which helped us with the new science program.

Her training in technology had been similar to her training in science. Her new skills in technology had been primarily acquired through school district in services and sharing of information with her colleagues. When asked about the role of technology in her program and her interest in using it, she commented:

> I do it largely because there is an expectation in my school that I must do it. Technology takes a long time and it can be really frustrating.

Leslie was aware of the ICT outcomes but said that she was quite lost when it came to any technical dimensions of technology. She stated that there was a place for technology in her classroom but that it was important for the classroom teacher to proceed cautiously with technology. Books, she stated, must continue to play and important role in the classroom and should be included in student learning activities. Leslie stressed that students need variety and that her role as a teacher was to make changes in instruction as needed by the students. Where possible, students needed to use more than one sense in order to learn and variety in instruction can stimulate students to utilize more than one sense (e.g., reading, hearing, touching). Leslie preferred hands on approaches to learning and stated that this was particularly important in the learning of science.

Technology was being utilized in Leslie's classroom in a variety of ways. During the progress of this research project, in the teaching of a social studies unit on the summer Olympics, Leslie had her students searching the Internet for information to be used in a student research assignment. Students also had opportunity to use a digital camera as part of their studies. In the math program, her students used the math tutorials that were included in the program materials. When asked about technology use Leslie stated:

> I do try to keep up by trying new things – each year I try to learn a few more things so that I don't get behind. That is one reason I volunteered for this project. I know kids like computers so I want to do more with them.

Leslie considered her strength as a teacher to be her ability to see the big picture when teaching students. She also stated that her exemplary organization skills strongly contributed to her effectiveness in the classroom. Her unit plans and lesson plans were detailed and materials needed for instruction were available. She felt that her flexibility and ability to adapt teaching as a lesson progressed assisted her in trying to meet the diverse needs of her students.

Leslie's Classroom

The classroom was spacious and every wall featured student work and an array of motivational posters and information items. There were two classroom computers, both Internet connected, that served as learning centres in the room. Students had freedom to use the computers when they had specific work to do on the computer or when they had completed other classroom work. There were 18 students in her grade three class which was the smallest class of students Leslie had enjoyed since she began teaching. She was enthused about the possibility to be able to do more things than in previous years, both in technology and other study areas, because of the small class size which made it easier for her to include learning activities that required considerable teacher assistance. For the most part, students came from average socio-economic backgrounds. One student in her class was autistic and was very interested learning activities that utilized technology. Another student had fairly serious behavior problems and had been assigned a part time teacher assistant.

Computer access in the school, beyond the two classroom computers, included a lab of 22 IMAC computers in the library. These computers were equipped with CD-ROM players and Internet access. A second lab of computers that did not have CD-ROM players or Internet access was also available to students. This lab was used primarily for operation of older software programs including math drill and practice games, basic word processing and keyboarding activities. The school's teacher-librarian assisted teachers and students with using technology. Leslie taught all core subjects to her homeroom class.

Profile of Roberta

She had been in the same school for over ten years and had primarily taught grade three. She enjoyed teaching science and was very interested in the use of technology in her classroom. She was active in her school and assisted with the school intramural program and was chair of the school fundraising committee. She volunteered regularly to serve as the co-operating teacher for student teachers seeking placements at her school.

Roberta had received a Bachelor of Education from the University of Alberta and had a minor in science.

In Roberta's school there had been a change in the availability of computers since the school year began in September. For the first two months of the school year there was a small computer lab in the library. However, only six of the computers were new enough to have CD-ROM players, to be hooked to the Internet and to have sufficient memory to operate many of the software programs available in the school. In late October a new IMAC lab was installed providing opportunity for 25 students to use computers at the same time. The upgraded facility made it possible for students to access the Internet and to utilize CD-ROM software available in the school.

Science was a favourite subject for Roberta. She was always thinking of new ways to teach science and to integrate technology in her teaching. She used technology regularly in language arts and science but did find it challenging to use technology effectively given the setting in her school. Her experience teaching science provided her with a solid understanding of the science program of studies. She had taken summer school courses on technology and was well aware of the ICT outcomes. Her students worked on the Internet and she had carried out a data base project on the theme of the Olympics in her social studies program. Her husband was a computer technician in another school and provided her with generous assistance in using school hardware and software. When asked to share her opinion about technology in her grade three classroom she said:

> I like technology mostly because I see that it could have benefits for students. They are interested in it and that interest is important. However, students at this age need lots of guidance on using technology. As a teacher I think computers have their place but it is also important that young students learn how to use a paper and pencil. I know that I should be teaching computers and the ICT outcomes but I also know I have to teach many other things as well so fitting it all in can be a challenge.

She also stated that she felt that her students learned best when they had opportunity to work with each other. Because of this view of student learning, she often had students work in pairs or groups. When asked how she thought others would describe her teaching style, she responded:

> Others would probably say that I am really structured and firm with daily routines. Kids at the beginning of the year say I am strict but once they get to know me they like me. I do have high expectations of students and I provide considerable variety in the ways I teach–especially now that I have a good understanding of the grade three programs. I also have a need to complete things that I start.

Roberta considered her strengths as a teacher to be her flexibility and adaptability. She was very patient and made very good use of the available resources in her school. Her school was one of the more poorly equipped schools in teaching resources and technology in the district. The school had recently undergone several renovations due to a changeover from being an elementary and middle school to an elementary school. The library and school computer labs were in the process of reorganization when the research study commenced.

Roberta viewed herself as a strong team player and knowledgeable about the grade three program of studies. She said that her accumulated knowledge, experience and planning were an asset to her grade three program. She also did her best to keep up on any changes and innovations in teaching by attending regular professional development sessions offered by her school district. She used many types of student assessment and generally followed her daily lesson plans.

Roberta's Classroom

Roberta taught in a school that drew from a low socio-economic area of the city. She had 26 students at the beginning of the research study and 28 by the end of the study. She described many of her students as quite disadvantaged. Her school had the highest percentage of single parent families of all the schools in her school district. Many students came from poor families. Very few families had home computers. The breakfast program in their school provided several of her grade three students with their first meal of the day. While the number of students who met acceptable standard and standard of excellence on provincial achievement tests was within provincial expected parameters, there was often a significant number of students in the school achieving below the acceptable standards. Most special needs students in her school were fully integrated in the regular classroom. Several of the students in her class had behavior problems. Two students had serious behaviour problems and many of her students had learning disabilities. There was a teaching assistant assigned to Roberta to work with the students who had learning and/or behavior problems. Roberta's classroom was a cheerful learning environment with the walls covered with displays of student work and inspirational items. Desks were arranged in pods and the room was spacious with ample room to move freely between student desks. There were two computers in the classroom and Roberta had access to a video projector when she wanted to use one of the classroom computers to project images to a screen.

Profile of Suzanne

Suzanne had been an elementary teacher for many years, and had taught grade three for several years. Seeking a change in teaching assignment, she had requested a transfer to move to a different school. In her first year at her new school, she was busy familiarizing herself with the routines of the school and the student population

She had a master's degree in elementary education and had completed a few university courses in science. She had a keen interest in both science and

technology and had been an active participant and lead teacher for many school and district professional activities on the topics of science and technology. Her favourite subject to teach was science, and she had been on several district science committees and had also worked with Alberta Learning on both Science and Social Studies curriculum committees. She had completed the Teaching, Learning and Technology summer institutes and had been a member of the Alberta Teacher's Association Science Council for the past six years.

Suzanne said that every year she had former students coming to visit her and saying that they were proud of the high marks they had received in science the previous school year. Suzanne felt that science was a favourite subject for most students in her class. She believed that science should be fun and that too many people, including some teachers, had an attitude that science is difficult. She wanted her students to do well in science and was particularly interested that girls would do as well in science as boys. She also organized her instruction so that if students were doing well with a science lesson she would keep going with it to capitalize on the enthusiasm. She preferred larger blocks of science teaching time so she alternated the teaching of social studies and science. For example, she would teach double blocks of science for two months and switch to double blocks of social studies for the next two months.

Suzanne had strong beliefs about technology in the classroom. She believed that students really enjoyed technology and that teachers should capitalize on this motivation and use the technology effectively. She said that she felt that at times educators and the general public expected too much of grade three children in the use of technology. She stressed that care must be taken to select appropriate software and student activities when teachers used technology. She felt that keyboarding was an activity her students disliked. Her experience with older software available in her school was that much of it was poor. She stated:

> Technology is only useful when it is used as a tool for learning. It can be an excellent tool if used in moderation. The human element must be in the classroom and it is the role of the teacher to provide an important balance.

In her school, there was a computer lab. There were also six higher-powered computers in the library. A computer was available for student free time use in the classroom. Suzanne's class was allocated at least one hour of computer lab time each week and she had opportunity to sign up for additional computer lab time. Suzanne was a very confident user of the technology and had done web pages and classroom projects on the Internet. She had her grade three class the previous years carry out a data base project as part of a science unit.

Suzanne's strengths as a teacher included her thorough understanding of the curriculum for grade three and her enthusiasm for technology. She was adventurous in the classroom and actively looked for innovations and implemented them in her teaching. She commented that she had thousands of resources and always was adding to her repertoire and changing the way in which she taught her classes.

Suzanne's Classroom

Nineteen student desks were arranged randomly in the classroom. There was ample space to walk around the desk of each student. Most students came from average to above average socio-economic backgrounds. The school had a fairly established population drawing from nearby communities in which many of the parents were working professionals. Very few students came from single parent families and there were few discipline problems with students. There were not any special needs students and most of the students were of average ability. Two thirds of the class were boys. One third of the class were girls. The classroom was decorated with bulletin board displays and many student learning resources were on shelves and tables in the classroom.

Teacher Planning and Student Orientation to Unit

The four participants had similar experiences in the planning for the unit and in the first few lessons of teaching the unit. These similarities are highlighted in the description of their teaching experiences for the beginning of the research

study. However, once the students progressed past the orientation activities to the unit, the experiences of each teacher became more unique.

All participants had taught the Animal Life Cycle topic many times previously. Each teacher had access to many personal and school resources that had been used in previous teaching of the Animal Life Cycle topic. However, none of the teachers had taught the unit using spiders or bears as a major focus of study. The teachers had not previously used commercially produced multimedia resources in teaching this science unit. None of the teachers had seen the Zoology Zone multimedia resource prior to the evening of the resource launching. Each teacher stated that they were sufficiently motivated to use the Zoology Zone multimedia resource CD-ROMs with their classes and agreed to make adaptations to their Animal Life Cycle topics of study to include the multimedia resource as a significant learning resource in the unit. The four teachers agreed that the two CD-ROMs would be a primary teaching resource in the unit and would be used to address concepts relating to the study of mammals (bears) and spiders (optional class of animals) as outlined in the Alberta Elementary Science Program of Studies. The research participants agreed that the first science unit of study with their grade three classes in September would be Topic E: Animal Life Cycles.

Over the summer vacation, each teacher began thinking about plans for the unit. All four teachers previewed the software using their home computers and classroom computers. During the initial preview of software, teachers did not encounter technical difficulty. Leslie and Roberta made arrangements to carry out some unit planning together and developed an Animal Life Cycle booklet that students would work on when they were not in the computer lab using the Zoology Zone multimedia resource. Together they reviewed their existing Animal Life Cycle topics and they made adaptations to the unit to include the Zoology Zone multimedia resource. Each of the four teacher participants made arrangements with the school teacher-librarian or school technology lead teacher to book sufficient class time in the computer lab to carry out the unit.

The teachers took different approaches to introducing the Zoology Zone Spider CD-ROM resource to students for the first time. Heather and Leslie both tested the CD-ROMs in their lab computers. Leslie stated that she had been 'burned' many times with assuming that what worked on the classroom computer would work in the lab. Both Leslie and Heather wanted assurance that each student copy of the CD-ROM worked in all of the available student computers prior to sharing the resource with the students. Leslie worked with her teacher-librarian to have the computers and library ready for students for the first day of the unit.

Heather met with the school's technology lead teacher and had the teacher join her in the classroom the day the Spider CD-ROM was introduced to the students. Prior to going to the computer lab on the first day of the Animal Life Cycle topic, Heather had the grade five students test the software as an extension activity in one of the grade five computer classes. The principal led the grade fives through the installation of the Spider CD-ROM to flag any potential problems and assisted Heather with any precautions regarding opening the software.

Roberta stated that she thought her first lesson of the unit was a disaster. She had taken her students to the library the first day of the unit and mistakenly assumed that since the software worked well in the classroom that it would work well in the computer lab. This was not the case. Adjustments had to be made to the virtual memory on each library computer and this was not evident until her unfortunate experiences the first day.

Suzanne was delayed in getting the unit started because of the challenges she encountered over school policy and practices regarding technology. The school's technology lead teacher was concerned about copyright issues and the suitability of the multimedia resource on the school computers. Suzanne was not able to proceed with commencement of the unit until the district computer consultant assured school administration that the software was suitable and approved for use by students. Then, adjustments had to be made to memory and operation guidelines for loading and installation of the CD-ROMs on the

library computers. These complications for use delayed Suzanne from starting the unit for more than one week.

Roberta, Heather and Leslie planned to use the video projector for initial introduction of the software to their students. They planned to project screen images from the Spider CD-ROM and to describe some of the design and navigation features of the software. Leslie and Roberta's demonstration went as planned. Heather's attempt failed as the video projector did not work for her. She resorted to a back up plan by having the students gather around her computer while she demonstrated some of the features of the Spider CD-ROM. Suzanne gave some general instructions to students about the design of the software once students had the CD-ROM opened on the library computers.

All four teachers guided the students through a general overview of the design of the CD-ROM including a sharing of the layout of learning zones of study, the site map, progression bar and pull down menu items. The purpose of the overview in all four classes was to introduce the new learning resource to the students and to inspire them to investigate the software as a learning resource.

All four teachers selected a variety of supplementary learning resources from their repertoire of science teaching materials and made these materials available to students throughout the unit. These resources included library books, magazines, posters, display items including models of animals, student activity sheets and videos that were in the school library or available from the district learning resources centre.

After the teacher led introduction to the Zoology Zone multimedia resource, the four teachers gave the students the Spider CD-ROM and gave them time (at least half of one class) to explore the CD-ROM. Suzanne and Leslie both assigned their students to individual computers and each student was given a copy of the Spider CD-ROM. Roberta divided her class of 28 into two groups. Half of the students were put into pairs or groups of three and given a CD-ROM to be used on one of the six available computers in the library. The rest of the students worked with books in the library. At the midpoint in the science lesson, the two groups switched. The teacher assistant worked with the

students on the computers while Roberta co-ordinated the other learning activities in a separate section of the library. Heather had her students in pairs in the lab. During the exploration phase her students were free to navigate anywhere through the software. All four teachers said that they felt it was important to give the students the opportunity to work with the CD-ROM on their own before moving to learning activities that were more teacher directed.

During the second class with students, Leslie tried to use the Network Assistant feature of the school network. This feature, when compatible with the teaching software, enables the teacher to share her computer screen with all students in a read only status. Leslie had planned to use this feature to explain to students various special features of the software. However, the attempt failed because only the text items would transmit to the student computers. The audio and graphics were not transmitted which resulted in an activity that was of little use to students. Leslie abandoned the plan and had the students proceed with exploring the CD-ROM on their own. Investigation into the problem uncovered that the design features of the Zoology Zone multimedia resource were not compatible with the Network Assistant software.

Teaching and Learning Activities

After the initial first few classes of orientation to the Zoology Zone multimedia resource, when students were given freedom to explore the Spider CD-ROM on their own, all four teachers directed students to assigned learning activities. Students began working on the learning activities in each of the learning zones of the CD-ROM (see Appendix A). In addition to the learning zone activities, there was a section of the CD-ROM called Explorations. In this section, there were activities that involved science skills for inquiry. The Explorations described learning activities that had to be completed in the classroom or as fieldwork. These workshop activities could be printed and did not require use of the computer and were intended to assist students in developing inquiry skills. Table 1 identifies the workshop activities and provides a brief description of each learning activity. The right hand columns identify which teacher participants utilized the workshop activities.

Table 1: Zoology Zone Explorations

WORKSHOP ACTIVITY	Suzanne	Heather	Roberta	Leslie
1. Arachnophobia Survey Chart: "Are you afraid of spiders?" *Students polled classmates and friends and collected data, organized it into a chart, and suggested conclusions from their findings.*	*√	√	*√	*√
2. Compare and Contrast Spiders and Insects *Collect information and enter on a chart Identify characteristics common to both in one column and unique features under the headings of spider or insect*	√	√	√	√
3. Design your own spider *Apply what you have learned about spiders to create an anatomically correct spider.*		√	**√	√
4. Chart your knowledge *Chart your knowledge of spiders, record information to compare and contrast the different way spiders take care of their egg sacs and spiderlings*			√	√
5. Charlotte's Web *What did you learn about spiderling parachutes? Make your own parachute like the one described in the story.*			**√	
6. Spider Vivarium *Use the information available to create a home for your spider. Follow the procedures set out for you.*			√	√
7. Spider and the Fly Board Game *Play the game and learn about spiders, their habitat, their benefits to man, dangers, and where they fit in the food chain.*		√		√
8. Web Watching *Follow the procedures to make a home for a spider. Observe web building and carry out the procedures to observe spider activity in a web.*			√	√
9. InterNet *Launch your web browser and to the spider information and links selected for you.*	√			**√

* activity was supplemented with additional classroom activities

** activity integrated in teaching non-science subject(e.g. Art, Language Arts)

Source: Zoology Zone: Investigations into the Animal Kingdom (2000).

Each teacher directed the students to use the Explorations workshop activities in the CD-ROM in a different way. There were also differences in the way in which each teacher approached the teaching of the unit and these differences are captured in the individual descriptions that follow.

Suzanne

Suzanne's approach to using the Zoology Zone multimedia resource was to focus on one learning zone at a time. Suzanne began her science classes with a question of the day that she developed based on one of the specific learning expectations that she chose from the science program of studies. Students were directed to explore the CD-ROM to learn about spiders by addressing the question of the day challenge; students would share their findings in a class discussion of the challenge following the computer use portion of the lesson. For example, in one lesson she posed the question, "How does a spider eat?" Students explored the CD-ROM looking for answers. Once students had discovered the answer to the question of the day they were directed by the teacher to proceed through the remaining learning activities in the "How I Eat?" learning zone.

Another day Suzanne posed the question, "What are the four stages of a butterfly?" Students searched the CD-ROM and eventually discovered the information in the "How I Grow?" learning zone. The students completed several learning activities about spider growth that culminated in a life cycle game, in which students were given challenges to identify the life cycles of many animals, one of which was the butterfly. Suzanne did not place restrictions on students regarding where they could go in the software to search for the answers to the question. During classroom discussions Suzanne took opportunity to direct students back to the CD-ROM for more information for the next lesson, or to go to other resources to answer new questions that emerged from the classroom discussion. Suzanne used the question of the day approach to begin and end each lesson. Interesting points of discussion from the end of one class would form the introduction or review at the beginning of the next science lesson. In several instances students would pose questions about the topic and Suzanne would lead a classroom discussion on the question and encourage students to search for the answer in the following lesson. Suzanne used the question of the day approach until students had completed all the learning zones in the Spider CD-ROM.

Suzanne gave her students several assignments that had to be completed and handed in to the teacher. With a few exceptions, students worked independently. Suzanne did not assign students to work with partners or in groups unless the learning activity specifically called for grouping (e.g., environmental game involving teams of two). Several of the Explorations activities in the Spider CD-ROM were assigned (see Table 1). Suzanne directed her students to complete activities 1, 2 and 9. In addition she had her students complete other activities that she had acquired from other resources. Students had to complete a Habitat mural demonstrating the food and water sources, shelter needs, enemies and space requirements for the animal assigned to them. Each student contributed one animal to the classroom mural. Students completed an art project demonstrating the concept of camouflage. One day, a series of learning stations were set up one day in which students determined the food needs of various animals by examining the mouth parts of the animals (e.g., beaks of birds, mouths of bears). The relationship between animals and environmental concerns was taught using an outdoor game in which students were assigned the roles of predator and prey. Suzanne used these activities to augment the learning activities in the CD-ROM. She also taught the students about other classes of animals including birds and amphibians.

Suzanne's approach to teaching with the Bear CD-ROM was considerably less structured than her approach with the Spider CD-ROM. She gave the students the Bear CD-ROM and invited them to proceed through it on their own. Suzanne posed challenge questions to them but did not follow up with classroom discussion as she had done with the Spider CD-ROM. Her students did not complete any of the bear Exploration activities. Suzanne explained that the direction she provided for the study of the Spider CD-ROM was to serve as a model for students in the study of the Bear CD-ROM. She let the students choose the activities they wanted to complete. Suzanne explained that she felt she was running out of time to spend on the unit and that her focus on spiders had taken longer than she expected. Some of her students proceeded through all the bear learning zones. Others did not. Suzanne said that she wanted her

students to use the Bear CD-ROM on their own and to make their own choices about what they wanted to learn about bears. She stated that she wanted the students to gain an appreciation for the study of bears but that the detailed knowledge in the CD-ROM was not a priority for her in teaching the unit.

Heather

Helen organized her students to proceed through the CD-ROM by zone. For example, if the concept for the lesson was habitat, then students would be directed to the "Where I Live?" learning zone in the resource. Students were directed to visit the specific learning zone during a class and to complete all the learning activities in the zone. When they finished the assigned activities, they could make personal choices to go to the "Did You Know?" section or other favourite portions of the CD-ROM that they had visited previously.

For most of the learning activities, Heather organized her students into pairs. She preferred this arrangement and students were comfortable with working with a peer.

Heather supplemented the learning activities in the Zoology Zone multimedia resource with many books and other text resources. She also had a preying mantis in the classroom for a few days. Two videos on animals were also shown to students.

In Heather's class, the study of spiders provided a model for the study of bears. In addition to learning about science, Heather wanted students to develop their skills in note taking. In each science class, as students explored one assigned zone of learning, one goal of the lesson was to complete a classroom chart, which summarized student findings from the CD-ROM. Heather challenged students with questions on one dimension of study (e.g., habitat for spiders). Students embraced the challenge by seeking details from their investigation of the CD-ROM. When sufficient information was uncovered, students would rush to the front of the classroom and share the information with their teacher. At intervals during the lesson, all students would be called together and Heather would list the student contributions in note form on a classroom

chart, under outline headings of study for the unit (e.g., habitat, food). Student contributions were summarized in point form. Heather invited students to assist her to simplify student contributions into a few key words under appropriate headings of study.

In several lessons the challenges to students took on an atmosphere of a scavenger hunt with students eagerly searching the CD-ROM for detailed information and competing with other students to find the answer first. Often, Heather would direct students back to the CD-ROM to find more information when she felt they were not entirely successful with the teacher assigned challenge. The classroom chart notes were used as a guide for students to complete their individual spider booklets. Heather directed students to take the point form notes, to create sentences, and to develop paragraphs in the appropriate sections of the spider booklet. Heather also created numerous workshop folders, which each student worked on with a partner. There were learning activities for each zone of study. Students could make their own choices about which assignments they completed. Heather said that as long as students were on task she would not interrupt their learning by directing them to progress to other workshop folder activities. Choices included completing activities from the Explorations on the CD-ROM. Heather had workshop folders made with activities 1, 2, 3 and 7 of the exploration activities (see Table 1). She augmented the Explorations activities with several other animal life cycle activities that were taken from her personal collection of spider activities. Students completed a spider shape book in which they recorded their findings about spiders.

During the study of bears, students were expected to take individual responsibility to make point form notes on their own, with less teacher direction than in the spider study. Each student was encouraged to apply the process modelled by the teacher during the spider study in locating and organizing information from the Bear CD-ROM. Heather assisted students by working with them individually or in small groups to complete note taking as well as to complete the assigned worksheet and centre activities.

Heather observed that students were not as excited about the study of bears as they were with spiders so she made adjustments to her classroom management during the bear unit. Students would spend half of the one-hour science class working on the CD-ROM and then would be given the choice to work on other software programs that had been loaded on all student computers. These included mathematics drill and practice games, language arts learning activities, and various word processing and key boarding programs. The variety in both her teaching of the bear unit and options for alternative computer program activities kept her students interested in learning. When students brought up questions about spiders or bears, Heather utilized a teaching opportunity to extend learning by bringing in samples of items or new resources that she felt would enrich student learning. For example, a discussion on spider food resulted in a follow up lesson in which Heather brought in an ostrich egg and a bird nest. Her focus was to have students understand the concepts of Animal Life Cycle rather than focussing on specific details regarding the life of a spider and bear, and she adjusted instruction daily to achieve this goal.

Roberta

Roberta approached the CD-ROM by learning zone, in a way similar to the approaches taken by both Heather and Suzanne.

Roberta encouraged students to complete assigned activities in a learning zone and then to work on the Animal Life Cycle booklet. This booklet included learning activities on various concepts in the science unit about which students were expected to provide written answers. Roberta supplemented the multimedia resource with two videos and encouraged her students to complete some comparison activities in which they contrasted grizzly and black bears as well as humans and bears. In a teacher directed discussion, the students contributed to the creation of a chart that illustrated comparisons between animals from the various animal classes (e.g., bear and spider, bear and human). She also integrated science learning activities with language arts and art. Students were assigned an activity where they had to illustrate spider and bear life cycles. They

had to explain their interpretation to Roberta to ensure that the concept of life cycle was understood. A guest speaker on frogs, from the local agricultural research centre, visited the classroom and brought tadpoles in various stages of growth as well as several frogs. The animals remained in the classroom as guests for one week and became a learning centre. Students participated in discussions comparing frogs with other animals of study including the spider and the bear. An art project, in which students used pipe cleaners to shape the frame of a spider, resulted in student developed papier mache spider models. Students applied their learning from the software to create spiders of their choice.

Roberta emphasized that she encouraged students to demonstrate their learning a number of ways. She also had students complete a journal several times a week. The journal entries gave students practice at writing and expressing their growing understanding about Animal Life Cycles. As the unit progressed, students were assigned workshop activities 1, 2, 3, 4, 5, 6, and 8, which were printed from the Explorations menu (see Table 1) on the CD-ROM, and supplemented with work sheets from the teacher's personal selection of Animal Life Cycle resources. Students had to complete assigned written activities and hand them in to the teacher. In each science class, Roberta and her teacher assistant acted as tutors and facilitators checking with students on comprehension of material covered, coaching students to complete assigned activities, and sharing in student enthusiasm for the learning activities presented in the CD-ROM. When a student demonstrated to the teacher that they had progressed through the learning activities and that they understood the major concepts in the unit, the teacher gave the student free time to explore the CD-ROM on their own.

In addition to the multimedia-based study of bears and spiders, Roberta taught the students about birds, amphibians and reptiles using a collection of print resources. She used the information from all topics of study to encourage students to draw comparisons between the different animal groups.

During the unit, several spider guests visited the classroom sink. Roberta used these visits as a teaching opportunity. The spiders were captured, put in a

student built vivarium (see Table 1), and examined by the students. The students discussed the spiders in their classroom. Students were also taken on a teacher-guided tour of the playground and were directed to spiders in their natural environment.

Leslie

Leslie proceeded through the unit utilizing a zone by zone approach for both the Spider and Bear CD-ROMs.

Leslie made several changes to her teaching plans as the science unit progressed. She adapted her plans based on her observations of her students during the spider unit and new ideas she became interested in as a result of discussions with the research group. She started the spider unit with students working individually on each teacher assigned zone. Students shared what they had learned about spiders during classroom discussions following each visit to the computer lab. Follow up activities to each lesson using the Zoology Zone multimedia resource included completion of workshop activities from the CD-ROM and other worksheet activities that Leslie had in her collection of Animal Life Cycle teaching materials. Her students completed exploration activities 1,2,3,4,6,7,8, and 9 (see Table 1). Students were also expected to proceed through the Animal Life Cycle booklet that she had created in her team planning with Roberta. She supplemented her unit with a generous assortment of books and other reference materials that were available on library and classroom tables for students to explore. During each science lesson, Leslie monitored student progress through the CD-ROM by recording which sites each student had visited. She obtained this information from the site map on the CD-ROM or from the pull down menus in each zone, which highlighted learning activities that each student visited. In the event a student had not completed all activities in a zone, she directed the student to complete the activities before revisiting favourite sites or exploring other parts of the CD-ROM. She posed challenges for students with the intent to encourage them to dig deeper for meaning and understanding.

After hearing about Suzanne's success with the question of the day approach in the spider study, Leslie incorporated this strategy into the study of the bears.

When students began using the Bear CD-ROM, Leslie became concerned with the engagement of students with the multimedia resource. Her class was quieter than she felt comfortable with and there was little discussion or interaction between students. She changed her classroom management to encourage more interactions between students by partnering students and having them explore the question of the day and the assigned zone together. This peer teaching approach was further encouraged in the follow up classroom discussions on the challenge question in which Leslie invited student findings and responses on their learning experiences. She felt that her science lessons needed to have more student activity than had been occurring during the study of the spider. Despite having enough computers and CD-ROMs for each student to work independently on the bear topic, she felt students would achieve the science objectives more effectively when there was increased socialization and communication between students and between the students and the teacher.

She also encouraged students to create questions for each other and to share these challenges during classroom discussions. Students were also encouraged to use the Internet to search for more information on bears and spiders. However, students became quite frustrated with this challenge due to their navigation and search skills. For example, students wanting to know more about spider webs entered "web" as one of the key words only to get directed to hundreds of sites on the topic of web sites. Leslie also supplemented the learning activities with explanations that assisted students in making connections about Animal Life Cycles by comparing different animals in the animal kingdom. Students were having difficulty with the concept of life cycle being illustrated in a circle. Leslie explored different ways to provide clarity on this concept and succeeded in assisting student understanding by integrating science with a music class where the popular song from the Disney film Lion King, called "Circle of Life," told a story in song about Animal Life Cycles. Several videos from the

district resource centre also served as springboards for further classroom discussion on Animal Life Cycles.

Leslie taught the spider and bear units on days when she had access to the computers. On days when she had science in her classroom, she used her supply of text resources to teach the other classes of animals in the Animal Life Cycle topic including birds, amphibians, reptiles and fish. Her approach to teaching the unit included learning activities in which students compared and contrasted the different Animal Life Cycles.

Assessment and Unit Closure

Each teacher was concerned that students be able to demonstrate what they were learning about animal life cycles. The four teachers also volunteered concerns regarding grade three provincial achievement tests. They stated that they felt pressure to complete all units of study in all subjects in the grade three programs early enough in the spring to allow time to prepare students for the provincial achievement tests in language arts and mathematics in June. Consequently, all four teachers were sensitive to the timelines for the science program and moved students through the Animal Life Cycle topic to ensure that they did not exceed two months of the school year on the unit. However, there were many differences in how the teacher participants addressed the matter of student accountability for learning.

Suzanne gave her students considerable freedom to learn about bears and spiders. Students were free to determine their own pathways for navigation through the CD-ROM. Her check on whether students comprehended the material presented in the CD-ROM was during her discussions with students on an individual basis or as part of the classroom discussions where the exploration activities from the CD-ROM were completed as a class. Her teaching focus was to direct students to increase their understanding of the general concepts of animal life cycles and to extend their learning to other animals. Her students completed various classroom assignments in which they identified if they were able to locate information on the CD-ROM to answer the questions that Suzanne posed to them each day. The assignments assisted Suzanne in determining if

students had good comprehension of the concepts in the unit and were using their own skills to learn as they progressed through the CD-ROM. She said that she was confident that students knew how to navigate through the CD-ROM and that they were sufficiently interested in it to take responsibility to answer the question of the day and to also explore other information about the animals of study. Suzanne recorded the progress of each student on the various assignments. She also gave a unit test at the end of the Animal Life Cycle topic. Students were given a study sheet that outlined the general concepts in the unit (e.g., adaptations, endangered, habitat). The study sheet was to assist students in studying for the unit test. The test had true and false questions and fill in the blank options. Suzanne indicated that the unit tests were early preparation in test readiness for the June provincial achievement tests.

Leslie, Heather and Roberta identified various assignments that had to be completed using the multimedia resource as the primary source for information and understanding. Roberta and Leslie's classes completed an Animal Life Cycle booklet which summarized information about the various classes of animals studied in the unit. Heather had her students complete notes and develop the information into a written report. All three teachers expected students to complete many of the Explorations workshops in the CD-ROM although students were given opportunity to choose the activities they wanted to complete.

Heather and Leslie both kept detailed records of student progression through the CD-ROM and completion of assigned activities. Heather developed a color-coded system of assignments which matched the color-coding on the CD-ROMs (e.g., pink for animal characteristics, orange for food). Heather's students progressed through the assigned work in the order determined by them with some students focussing more on activities from one zone of study and others completing activities from a variety of zones. Leslie expected students to complete a research project on an animal of study of their choice. This assignment was to include a 'web' outlining the information about the animal under several headings. This paper and pencil exercise involved investigation of books and Internet. A few students chose to use the Internet but their attempts

to locate information were unsuccessful. Leslie had intended to have students create their own mini multimedia presentation of an animal of study using the Kid Pix program available on school computers. However, as the science unit progressed, she abandoned this idea because of the challenges she felt students would have with the assignment and the frustration she anticipated that it would cause for them and for her. Instead, students completed their Animal Life Cycle booklets which included study into at least one animal of their choice. She indicated that the student journals also gave her a strong indication of student understanding of concepts in the unit. Heather and Roberta did not use tests to assess student performance. For the most part, they preferred to use student assignments and classroom activities to assess student learning. Leslie, like Suzanne, did give a unit test. She also utilized fill in the blank, matching and true and false response formats to begin preparing her students for June provincial achievement tests.

Reflections of Teachers

Use of Constructivist Pedagogy

Following completion of the Animal Life Cycle topic, I asked the teacher participants to react to my interpretation of their experiences in the classroom. I shared with them a list of the characteristics of constructivist pedagogy (as stated in Chapter 2) and my observations of their use of constructivist pedagogy. The chart following summarizes each teacher's implementation of the characteristics in the teaching of the Animal Life Cycle topic. It is evident from the data that the four teachers demonstrated some of the characteristics of constructivist pedagogy in their teaching experience with the Zoology Zone multimedia resource.

Table 2: Constructivist Teaching To what extent did your science teaching encourage the following characteristics?	R (rarely)	S (sometimes)	C (consistently)	M (mostly)
1. Curriculum is presented whole to part with emphasis on big concepts.	Leslie Heather Roberta	Suzanne		
2. Pursuit of student questions is highly valued.	*Leslie *Heather	Roberta Suzanne		
3. Curricular activities rely heavily on primary sources of data and manipulative materials.		Heather Suzanne	Roberta Leslie	
4. Students are viewed as thinkers with emerging theories about the world.	**Heather **Suzanne **Roberta **Leslie			
5. Teachers generally behave in an interactive manner, mediating the environment for students.				Suzanne Leslie Heather Roberta
6. Teachers seek the students' points of view in order to understand students' present conceptions for use in subsequent lessons.	**Leslie **Heather	Roberta Suzanne		
7. Assessment of learning is interwoven with teaching and occurs through teacher observations of students at work and through student portfolios.			Roberta Leslie	Heather Suzanne
8. Students primarily work in groups.		Suzanne	Heather Roberta Leslie	

* agreement with principle but did not plan instruction to reflect the principle.

** occurred more often in other subjects.

Source: Brooks & Brooks, (1993)

The four teachers agreed that constructivist pedagogy has a valuable place in the elementary classroom. However, they indicated that there are limitations for using constructivist pedagogy in grade three classrooms. For example, the characteristic "Pursuit of student questions is highly valued" was viewed by the four teachers as a valuable teaching characteristic. However, they pointed out that, despite placing value on the characteristic, they did not consistently utilize the strategy. The same viewpoint was presented for the characteristic "Viewing students as thinkers with emerging theories". The teachers indicated that they may view students in this regard, but that their teaching activities might not always reflect this view.

The teachers also stated that they felt they were more 'constructivist' in their teaching in subjects other than science. They pointed out that in a social studies unit, they would have assessed their constructivist pedagogy quite differently than they did for the Animal Life Cycle topic. Another interpretation the teachers offered was that their use of constructivist pedagogy at the beginning of the grade three year might be different from their experiences later in the year. For example, as grade three students mature and develop many skills during the school year, their ability to pose questions and offer their emerging theories about the world also increases.

Applications of Computer Technology

The four teachers were asked to assess their experiences with the Zoology Zone multimedia resource in relation to the three most common applications of computer technology in teaching.

The teachers were unanimous in their assessment that the Zoology Zone multimedia resource was primarily used for CAI. The design of the resource assisted the teachers by presenting to students a significant portion of the content of the Animal Life Cycle topic. The teachers trusted the multimedia resource to provide students with expert content and suitable learning activities and to address many of the student learner expectations set out in the Alberta Elementary Science Program of Studies. The four teachers felt that the Zoology Zone multimedia resource was very useful as a computer assisted instruction resource.

The four teachers also agreed that the Zoology Zone multimedia resource was used, to a limited extent, for information and communication. However, they did not feel that this was a significant application of the multimedia resource. At the completion of the unit, the teachers reviewed the ICT outcomes and were delighted that many of these outcomes had been achieved in the teaching of the Animal Life Cycle topic. However, these outcomes had not been planned for in the teacher planning of the unit. The student achievement of many of the ICT

outcomes was an added benefit that occurred simultaneously with the use of the Zoology Zone multimedia resource for CAI in science.

The Zoology Zone multimedia resource was not used as a cognitive tool. In the planning stages for the unit, Leslie and Roberta had planned to have their students complete their own mini multimedia project. They intended to have their students create a Kid Pix or HyperStudio multimedia presentation on an animal of study. However, as the unit progressed, both teachers abandoned the initiative. They felt that the computer skills the students would have to acquire in order to develop a multimedia presentation would demand more time than was available for the teaching of the Animal Life Cycle topic. They indicated that the Zoology Zone multimedia resource did provide an excellent model or template for students to use to design their own presentations. However, the teachers concluded that the activity would be more appropriately placed with students in higher grades. Suzanne indicated that she would have liked to have the students organize the data that was collected from the student poll activity on arachnophobia (see Table 1) into a data base or spreadsheet. The data from all students could be included. Then, students could sort and organize the data to draw conclusions from different combinations of data. However, as the science unit progressed, Suzanne decided against the learning activity due to time limitations and a reluctance to deal with the many challenges that would have to be addressed in teaching the students about spreadsheets and data bases. The activity, she stated, would be more successful if she attempted it later in the year when the students had more computer skills and were more settled in classroom routines. Heather had no interest in pursuing use of the Zoology Zone multimedia resource as a cognitive tool. Her own experiences with spreadsheets and data bases was very limited and she did not feel confident to utilize them in the teaching of her grade three students.

Teachers found the Zoology Zone multimedia resource very useful in meeting the SLEs for Understandings in the Animal Life Cycle topic. However, the resource had limitations in providing learning opportunities that met the SLEs for attitudes, and skills for science inquiry. Several of the Explorations activities

were used by the four teachers in the spider study but none of the teachers used the Explorations available in the Bear CD-ROM. It was evident that the teachers did not place as high a priority on pursuing the Explorations as they did in having students complete all the learning activities in the zones of study. The primary focus of the learning in the zones of study was acquisition of knowledge.

Chapter Summary

The preceding descriptions document the individual approaches taken by each teacher in the teaching of the Animal Life Cycle topic. The descriptions were obtained from data gathered in individual interviews with each teacher and from visits to each classroom. Additional information was obtained from various student work samples and from teacher planning documents that teachers provided to the researcher.

CHAPTER FIVE
ANALYSIS OF DATA

The data collected were grouped into four categories. Since this study was focussed on teacher experiences with the Zoology Zone multimedia resource as used in grade three science teaching, the four categories are to be interpreted from the standpoint of teaching with a multimedia resource. The findings are illustrated with the words of the participants as they shared personal experiences in the group interviews and individual interviews. Each of the categories is interpreted in relation to teacher experiences with the multimedia resource. The four categories are (a) teacher planning, (b) student learning, (c) role of the teacher, and (d) teacher learning. The findings are discussed in this chapter in relation to the four categories. Interesting findings which I refer to as puzzles in the data, are discussed following the presentation of categories.

Teacher Planning and Multimedia

Planning is an essential activity teachers undertake to ensure that they are providing a positive learning environment for students. In the case of a teacher using a multimedia teaching resource, planning involves identification and effective utilization of the resources required in the teaching of the unit as well as development of a unit plan which outlines teaching strategies, student learning activities and assessment activities.

Two sub categories emerged under the category of teacher planning. The process of unit development with the Zoology Zone multimedia resource as the primary resource forms part of the discussion of teacher planning. Technical considerations, specific to the use of the Zoology Zone multimedia resource, complete the discussion of planning and multimedia.

Unit Development

In the early stages of the study teacher participants spoke about the relevance of the Zoology Zone multimedia resource to the teaching of grade three science. In the first group meeting I shared the three reference documents

that might assist teachers in preparation for teaching the Animal Life Cycle topic. The three documents were the 1996 Alberta Elementary Science Program of Studies, the Information, Communication and Technology outcomes (2000) and the Zoology Zone Teacher Guide. When these teacher resources were distributed, the four teachers said they had used the elementary science program many times. All four participants were also aware of the ICT outcomes document but discussed varying approaches to utilizing the document. Each teacher also had a copy of the Zoology Zone multimedia resource teacher guide and said they had perused the document.

The Elementary Science Program of Studies figured prominently in unit planning. Teachers indicated that they used the document to identify the specific learner expectations which served as the guideline for planning all components of the unit. The ICT outcomes were referred to but did not form a significant role in teacher planning. The Zoology Zone multimedia resource teacher guide served as general information and was not a significant reference resource for any of the participants.

During the first group meeting participants talked about their planning strategies for the science unit.

> Lynne (interview facilitator and researcher): Can we go back to planning documents. I am wondering if you referred to the program of studies, the ICT outcomes or the teacher guide?
>
> Roberta: When we (Leslie and I) put together our little unit plans, we went through the ICT outcomes and the program of studies to correlate what the expectations were for students.
>
> Leslie: We tried to cover as much of the ICT outcomes as we could in one unit or less (laughter). Because we were given lab time for this research project we are trying to cover everything we can because we may not be able to get back in there again for a long time.
>
> Suzanne: Well of course the science outcomes are bang on. And the ICT outcomes – well in our school, since the outcomes are so general we are breaking them down. So grade ones will do this…grade twos this and so on. I see that the CD-ROM will do pretty good coverage of all the outcomes.
>
> Lynne: Teacher guide? Anyone use that?

Leslie: Yes -- read it but didn't use it! (Others agreed – laughter)

Lynne: How about you Heather? Same situation?

Heather: Yes basically. I had my unit developed before and I have always kind of gone through the unit and then done some research. This year we are using the CD-ROM as part of the research.

Discussions later in the project with the individual teachers about planning demonstrated that the science program of studies was the primary teacher reference for determining progression through the unit using the Zoology Zone multimedia resource.

Lynne: So you start with the science curriculum first and then go to the ICT outcomes?

Leslie: The goal would be the science curriculum because the ICT goals are not specific to one subject area as they are spread throughout grades so some will be met through science and some will be met through social studies, some in language arts. A variety.

Lynne: You felt you had responsibility to make learning relevant to the science program study – you had to conduct lessons so that the learning was relevant to either the student learner expectations (SLEs) in science or the ICT outcomes?

Suzanne: My time was well spent using Zoology Zone multimedia resource, as the resource is relevant to the science SLEs. That is why it is SO SO important that teachers make sure the resource – any resource that your are using with kids – meets the SLEs. If it doesn't meet the SLEs then why are you doing it?

Leslie: You don't have time as a teacher to waste time figuring out if the resource fits the program of studies.

Suzanne: That is another reason why we wanted to buy into this project. The science SLEs were in the resource. This past week when I was in Kananaskis previewing science videos it just amazed me the number of people who do not know the curriculum They will be previewing a video and say it is great but it does not fit in anywhere in the curriculum! If it is a big stretch to fit then don't buy into it. This CD-ROM is a strong match and that is why I think people will buy into it. It is part of our jobs to make sure we are addressing the SLEs.

Leslie: In the orientation to the project you gave us a paper that showed us how the SLEs were addressed in the CD-ROM.

Roberta: Yes at the beginning of the project we knew the SLEs were addressed.

Suzanne: I bet you would have had a very hard time getting anyone to volunteer for this project unless it was clear early in the project that the resource met the SLEs.

Roberta: Yes. We look for things that we think will work.

Leslie: Things that can help us in the short period of time we have to address all that we have to. This may be a more effective tool than many other resources that we have because it covers a lot of the SLEs.

Suzanne and Roberta: Agree!

All four participants previewed both the Spider and Bear CD-ROM before proceeding with detailed unit planning. Next, they determined where the CD-ROM would fit in the Animal Life Cycle topic after they were satisfied that the resource was helpful in addressing the science program of studies SLEs. All four teachers discussed the importance of being satisfied that the software was relevant to the science unit before they proceeded with further planning. Since all teachers were very familiar with the science program of studies, they proceeded to adapt their existing Animal Life Cycle topics to include the Zoology Zone multimedia resource. They became familiar with the content in the software and determined other classroom activities to supplement the software. All four teachers utilized the software as the primary resource for the study of spiders and bears in the Animal Life Cycle topic. The two CD-ROMs were supplemented with other teaching resources including books, and pictures.

The teachers proceeded differently in the process of unit planning. Suzanne said that she pulled resources from all over the place to make science interesting for her students. Sometimes she would start with the resource and then consider how it matched the SLEs and sometimes she would start with the SLEs and specifically look for an appropriate fit with a resource. She utilized the Spider CD-ROM as one learning resource in the general overview of animal life cycles. Students used the Bear CD-ROM to investigate the study of mammals, and the students then were encouraged to draw comparisons between the two classes of animals. The other three teachers indicated that they previewed the two Zoology Zone CD-ROMs and then adapted their existing units to best utilize the resource to meet their unit objectives. All four participants indicated that the

teacher made choices about when to use the multimedia resource and when to use other resources. When the students had access to the computer lab the multimedia resources were used. However, teachers planned other learning activities in which the students utilized various print resources, audio-visual resources, listened to guest speakers and completed student assignments.

Technical Considerations

Access to computer technology, reliability of the technology, and support for using the technology were concerns of teachers during the planning of the Animal Life Cycle topic. Following a preview of the software, all four participants struggled with technical difficulties. Concerns included loading of the software on school computers, computer memory limitations, and compatibility with operating software, copyright issues and the use of peripherals with the Zoology Zone multimedia resource CD-ROMs. Prior to distributing the software to participants I had been assured by the school district technologist, the software developer technicians and the school district helping teachers that the configuration of computers in the participating schools was compatible with the Spider and Bear CD-ROMs. Despite this assurance, technical issues were the primary discussion item during the initial individual interviews with teachers and the first two group meetings.

> Lynne: Tell us about your experience and then I have some specific questions that I may ask to direct the remainder of the discussion. You okay Heather – ready to tell us?
>
> Heather: For planning I went through the CD-ROM at home. I thought I want to know what is in there. I need to know the kind of information that is in the CD-ROM. Once I went through it I thought it looked really good and at a good level for the kids. I went to our tech person at school and I said, "How do I get this on my computers?" She helped me out. One of the problems we had was the computers said that we did not have enough memory so we had to fix that problem. I didn't know what I was doing and it was a bit of a challenge for her but we did get it done. Then I had her come into the first class with me and she would prompt the kids through the downloading process. Because I thought that if I did it by myself who knows what could happen. That was fine. I had wanted to use the overhead projector with the CD-ROM to show

the kids what everything looked like. But of course that wasn't working either so I had them sit on the floor and I very briefly showed them the CD-ROM on my computer.

Lynne: Maybe we will go all around the table on planning and give the rest of you a chance to share. Feel free if you have any questions to jump in. Roberta what about you with planning?

Roberta: Similar to Heather. I went through the CD-ROM with them as a class showing them how to the use the CD-ROM and progress through it. We looked at where to click and so forth. And then we went to the library where we have six computers that have CD-ROM players. I put the students into groups of two or three. Half of the class was to be on the computers and half the class was in the library side. Then half way through the class we swapped. The first time was a disaster. I had not tried the CD-ROM on the library computers. I had assumed that because they worked in my class that it would work on the G3 in the library. We got the message that there was not enough memory. We mucked around and were not successful. Then I got the vice principal who found that we did not have enough virtual memory. We pushed it up and then it worked. I should have checked into that first.

Lynne: Suzanne what about you with planning and progress?

Suzanne: Planning – I read the teacher package and reviewed the CD-ROM. The biggest problems for me were getting them on the computers. That is so...frustrating for me. The teacher-librarians helped me but she has some knowledge of computers but she needs permission for everything from central office before she will move on something. It drives me crazy. Nothing is easy. I bet we wasted three or four days getting things to work.

Leslie: And that did get resolved. I know I had to talk to her about copyright issues.

Suzanne: That is so frustrating. I can see why some teachers give up. You have to keep at it right.... And your teacher-librarian or whoever your tech help is also has to keep at it. We had trouble with QuickTime installer and then we needed permission to use that. Then I needed her to get permission to use the CD-ROMs and I don't know what else but it took time to get the CD-ROM operating.

Roberta: We had to install QuickTime on some computers but it worked. Then we worked directly from the CD-ROM.

Lynne: I think the problem in Suzanne's school was that the teacher-librarian was being very careful about potential copyright issues. After I talked to her and ensured her that there was full clearance for the schools to use the CD-ROM she was fine. She

had already found that out by the time I got to talk to her. I guess she had spoken to someone at central office.

Suzanne: Every time I talked with the teacher-librarian she would say she had to call the district computer consultant. I wish they would just let me at it! What I find frustrating is that the kids have to install the CD-ROM themselves but then the disk won't eject. You have to shutdown and reboot to remove the disk.

Lynne: Heather found the same thing.

Suzanne: That is frustrating. The technician is anxious to find out why that is happening.

Lynne: I will get on that tomorrow. Now, Leslie how about you?

Leslie: I am learning about the CD-ROM, and I am learning about Network Assistant and I am learning about computers and also learning about the computer projector. All this is new! I have got through all my lessons.

Lynne: And who is teaching you?

Leslie: Dave (laughter)

Lynne: and Dave is your school teacher-librarian and also pretty good with computers?

Leslie: Yes he is. I had tried all the CD-ROMs ahead of time to make sure they were working before I took my kids to the library. I have learned that the hard way through past experience.

Roberta: I also had to try it several times.

Heather: I had Allen, our principal, get some of the grade fives look at it and he had come back to me and said oh they are not working. So after school when I had some time I went to the computer room and grabbed Diane, our computer tech, and I said help me out with this. We got it – I guess it was the memory thing.

Suzanne: And also they don't shut off with Netscape. Then lots of times it won't read it. And lots of times the kids don't shut down the programs and that causes problems because then I have to go back and shut down each kids computer.

Lynne: Okay – it looks like most of the technical difficulties are being handled. I will address the problems of Heather and Suzanne with the multimedia developers tomorrow. It has something to do with your network administration and can be solved. I will get back to you tomorrow.

The above excerpts were taken from the second group interview after the four teachers were part way through the use of the Spider CD-ROM. For

Suzanne, the experience of getting started was most frustrating. She encountered roadblocks with her school computer technician on matters of loading the software and regarding interpretation of district policy regarding copyright issues. Her support system in the school made it difficult for her to proceed with implementation of the unit. Each time she ran into a problem, other district personnel had to be brought in for direction on addressing the problem. Her freedom to proceed on her own was blocked by the procedures for software use in her school.

For Heather, frustration was evident but she had planned for potential frustration by having checks in place early in the planning phase. Roberta, despite planned testing of the software on her classroom computers, experienced disaster with her first lesson using Zoology Zone multimedia resource. Although the test run was successful on the classroom computers, the software did not work on the computer lab computers. Leslie experienced the fewest technical challenges. Perhaps her ongoing support from the teacher-librarian who has a strong computer background helped. Also, Leslie had tested the software on every computer that students would use.

The teachers said that they wanted assurance that they had sufficient access to computers to utilize the multimedia resource. School schedules for computer lab usage had to be arranged by each teacher. All teachers had to juggle timetables to get access to the computer technology to use the software. They also had to be flexible with the progress of the science unit based on when they could access computers.

Each teacher had different ways to cope with the frustration of getting started. Nonetheless, the frustration and the effective coping with the frustration caused by technical concerns were significant challenges for the teacher participants.

On matters of teacher planning, teachers found that using the multimedia resource demanded more effort and more time from them than teaching the unit without the multimedia resource. Teachers had to depend on other people and were affected by other factors over which they had limited control. The planning

for implementation as well as the time teachers required to preview software and assess its relevancy to the program of studies were concerns presented by the four teachers. Each teacher had to rely on other staff members in the school in order to proceed with the multimedia project. Teacher-librarians, school computer technicians, and in Suzanne's case both school and district administration, were involved in affording the classroom teacher the opportunity of using the Zoology Zone multimedia resource in school computer labs.

Student Learning and Multimedia

The teachers' experiences with Zoology Zone multimedia resource were influenced by their views of how students learn. Teachers plan for instruction based on what they believe about student learning. They attempt to develop instructional strategies that result in the highest possible incidences of student learning. Examination of the data in this research project provided information about teacher views of student learning when students are utilizing multimedia resources. Not surprisingly, many of the general views teachers held about student learning were applicable to student learning when using multimedia resources. However, some differences emerged about student learning that was specific to the nature of multimedia resources. As an outcome of the use of the Zoology Zone multimedia resource in the teaching of the grade three Animal Life Cycle topic, teachers presented their observations about student learning from the multimedia resource. Teacher views of student learning with multimedia resources were examined in four sub categories, which were identified in the data collected. The sub categories, which assisted in organizing the presentation findings under the category of student learning, were: (1) student freedom to explore the multimedia resource, (2) teacher directed learning, (3) social dimensions of learning, (4) student directed learning, and (5) learning distracters.

Freedom to Explore

All four teachers discussed the importance of allowing students sufficient freedom to explore the CD-ROMs as part of their learning process. At the

beginning of the science unit with the introduction of the Zoology Zone multimedia resource CD-ROM, students were given opportunity to explore the software with little or no teacher direction. Later in the unit, the freedom to explore was exercised as part of enrichment free time activities and in options extended to students in the choice of research projects and assignments.

Lynne: All of you made a professional choice at the beginning to let students freely explore the CD-ROM in the initial implementation stage. I am curious why you did that.

Roberta: From my past experience anytime kids get a new 'thing' – whether it is a workbook, textbook, math game I always give them five to ten minutes to look through the whole thing. I have learned that if I try to direct them to let's say go to page 5 of a new book I will have 15 other kids all on different pages in the book. Their attention is better once they know a bit about the 'thing' we are going to look at. Then when I want to focus their attention it is easier to do so.

Lynne: All three of you are shaking your heads in agreement with Roberta.

Leslie: I agree and I do it as well but it is the same with adults-- we will flip though it.

Roberta: I agree – that is what we do.

Leslie: But with technology I know that with me you had better give me time to play with it too. Before you start teaching me anything about it I need to preview it. I do the same things with my kids. I let them just play for awhile.

Heather: The other thing I found is that when I went through the CD-ROM on my own it was really easy to follow. So I knew that the kids would be fine to go explore on their own. I felt that they would not have trouble with it. I knew they would be fine. I felt confident that because of the way the CD-ROM was set up that they would be able to move through it without difficulty. It didn't lend itself to a situation where kids would be calling for help ---'Help, Help – I am stuck! I didn't anticipate that would happen with this CD-ROM.

Leslie: Yes – they seemed to know what to do and the CD-ROM got their attention.

Lynne: Suzanne what about you.

Suzanne: I agree. And I think that one of the greatest things that you can give kids is to give them the 'lay of the land' with anything – a CD-ROM, book or whatever-- then it is empowering to kids and they have control over where they want to go to. That is why I feel

quite comfortable with exploration afterwards because if the kids know how it works then they can figure out how to get there.

Lynne: Good point.

What you are saying is that something that you know from your general teaching repertoire is that you have to give kids a chance to explore both at the beginning and end of a significant learning activity.

Roberta: Yes that helps reduce the nightmare in the class. What I mean is the classroom management.

As the study progressed, teachers utilized increasingly more teacher directed instruction but they consistently returned at points throughout the unit to give students a choice about determining pathways in their learning. That is, students determined their sequence and pace of learning by making personal choices on how to proceed through the CD-ROM. After the initial exploration phase of the CD-ROM, teachers identified expectations for students that involved the students navigating through specific sections of the multimedia resource. Provided that students addressed the identified assigned task, the teachers gave the students freedom to search through the CD-ROM at will.

Lynne: You did a preview of the software and let the students investigate on their own. Then, even when you directed students that they had to be in one zone for the day you didn't impose an order on how they proceeded through that zone. Was that an issue?

Suzanne: What do I care – even with a book -- if they read it from the back forwards I only care whether they understand it. Like in math – that is what they are telling us to do with students. As long as the kids arrive at the goal that there are many different ways to get to the end objective. How they get there doesn't matter. That really reinforces that -- let them explore their own way to learn.

Lynne: New teachers may not feel as comfortable with that? What if you are a real logical sequential type of teacher? Do you think you would impose that you have to do chapter one before two or activity one before activity two in the CD-ROM zone?

Roberta: But even some of us very logical sequential people can learn new tricks.

Suzanne: I think that is a key issue. Letting kids find different ways to get to the end. I think we should really encourage that.

Leslie: We are doing more and more of that in our classes.

Lynne: So Roberta as a self proclaimed logical/sequential teacher does it bother you when students go off on their own and approach learning back to front or in a different order than you would use?

Roberta: Not any more. But it used to bother me. If you would have asked me that 10 years ago it would have driven me nuts.

Lynne: Why do you think that is that you have changed?

Roberta: I think I have come to the understanding that as long as we all get to the same end point it doesn't matter how you get there. If you did it in alphabetical order or scrambled it wouldn't matter. On the CD-ROM one section was not dependent on the next section so it didn't matter what order you did it. It is a different situation if one bit of learning is a pre cursor to further learning. Then the order would be more important.

Lynne: Understanding that about learning may be useful. If kids have some control over their own learning pathway they may chose a different pathway than the teacher may select for them.

Suzanne: Which is pretty cool. Because it also does a lot for their self-confidence.

Lynne: That they start to understand more about how they learn?

Suzanne: Yes -- and that they can be proud that they found a different way to do it. I think that is really neat – not putting kids in a box.

After students had completed assigned activities, teachers gave them the option of exploring the CD-ROM on their own by visiting new screens or revisiting activities of choice. Teachers did not discourage students from visiting any screens of the multimedia resource. All teachers left the choice to students as to how they would explore the "Did You Know?" zone.

Lynne: Did you spend a day on "Did you Know?" or leave it to them to go to where they wanted to go?

Suzanne: Mine was free time for them.

Leslie: For me when they finished one of the zones they could go to the "Did You Know?" section and work on any of the quiz questions in that area. A lot of the kids went there. It is the same with most things – a couple would go and word spreads and they all go there and they all tell you that they have been there.

Suzanne: I think it is an experience for them.

Lynne: Your kids really liked that.

Leslie: Oh yes for sure. They would often end up on that site.

Lynne: Did they pretty much go through all the riddles?

Leslie: I am not sure whether they did or not. I doubt that all of the kids went through all of them.

Lynne: Heather what about you?

Heather: Again, once we had done the assigned lesson for the day then the kids were free to go wherever they wanted. Some ended up there and some didn't.

Lynne: You weren't interested in making sure they completed that area?

Heather: No – it was more for fun and reinforcement.

Roberta: For me it was free exploration.

Teachers also gave students freedom to choose other learning activities that were included as part of the science unit. Heather and Leslie volunteered their approaches to student choice in learning activities:

Lynne: Your students finished spiders and are now working on bears. What is the next step? Do they move to the research project now?

Leslie: It is a pencil and paper activity. Characteristics, habitat for whatever animal they have chosen.

Lynne: They can pick any animal?

Leslie: Any animal. I find that most kids will pick according to the animal that they like not because there is a CD-ROM attached. I don't see them all running to bear and spider just because there is the CD-ROM there. I can see them picking frogs and snakes because that is what they like more so at this age.

Lynne: So you allow them to go with animals that they are interested in.

During my visit to Heather's classroom, students were working on the Explorations that were printed from the Spider CD-ROM. Each workshop was included in an assignment folder. Students were paired and given the choice of which workshops they wanted to complete. There were a total of four possible workshops and each student selected activities to complete. During my visit, to the classroom most pairs completed two of the activities. Heather explained that she wanted the students to apply learning from previous classes and that their interest in specific activities would be reflected in the choices of workshops

selected. She discussed that if she mandated the workshops she felt that some students might not have been as interested in completing the challenges. In Roberta's classroom, students had choices on research topics and types of artwork selected as part of integration activities with the art program. Students were given direction on papier mache techniques and, applying information about spiders, they constructed spiders of their creation and choice. In Suzanne's classroom, the bear unit was handled by students choosing their own learning pathways. Students were given the CD-ROM and they determined what they wanted to learn about bears and how they would proceed through the CD-ROM.

The teachers felt there was value in giving students opportunity to independently explore the multimedia resource. The resource captured student attention and maintained their interest. The instructional design facilitated student freedom to experiment with the special features and make personal decisions about how to proceed through the various screens of information and interactivity.

Teacher Directed Learning

In the spider unit, all participants included teacher directed learning activities. Teachers began the unit with an open, largely unstructured approach to learning by letting the students freely explore the resource during the first lesson. After this orientation to the resource, the teachers applied a tighter structure with teacher directed expectations for student learning.

> Lynne: The other thing is that all four of you imposed some structure on your teaching after the initial exploration phase. Suzanne did a bit different from the other three. But all of you were kind of reining the kids in – why did you do that?
>
> Roberta: I did it for accountability. I know the kids were to read through the first section but I want to know that they did all the activities in a section. I want to make sure they cover the areas I want them to. Otherwise many would only play the games. Like on the days we did the workshop the kids were given the sheet and told they had 30 minutes. Most were done in 15 minutes and then knew they had time for free exploration but I did want them to complete the assigned task. So it made the students accountable for some of their learning.

Lynne: You wanted the kids to show that they were learning by putting the proof of that on a worksheet.

Roberta: Yes. At least for some of the kids.

Lynne: What about the rest of you?

Leslie: I think I did it similar. The workshop sheets served as a guide for the kids. It encouraged them to relate to more of the content than just the games. Some of the material was not as exciting for them and they would just skip over it the first time. The exercise sheets made them go back and get a second try at the information.

Lynne: Anyone use discussion or another method to test learning?

Leslie: We do a lot of discussing before and after each lesson. We talk about the goal for the day (e.g. Habitat) and focus on some ideas. At the end of the class we do a closure activity – when the kids would hand back the CD-ROM we would talk about what they learned.

Lynne: You didn't use the exploration sheets but seem pretty confident that your students learned?

Suzanne: We did it as a large group and not as individuals. We went through he workshops as a whole class.

Lynne: I guess what I am looking at here is that we can teach in a traditional classroom setting and direct students to read chapters 1 – 3. But how do you know they have actually done that? What checks and balances are there in a multimedia resource for this kind of thing? You are telling me you had them report back to you, to discuss, to complete workshops and other things.

Leslie: It was the posed questions and discussions that pointed out to me whether a kid was having trouble or not. For example a student may say, "I can't find the answer."

Suzanne: Even with a textbook you have to make the students accountable in the end. I think that is what all of us here were doing. We had different ways to get the students to show they were accountable.

Lynne: Each of you did have a system didn't you? Heather, anything to add?

Heather: No I think it has pretty well been covered.

Lynne: If you would have given the kids the CD-ROM and said they could do what they wanted for a week but that they had to learn about spiders, do you think they would have come out learning as much as they did with the teaching procedure you used?

Leslie: I think they would have known a LOT but I don't think they would have learned as much. I know there were several kids who struggled on the workshop pages because they had skipped over those areas. By making them go back they finally did learn what was in those areas.

Heather: And I know that I had to SEND my kids back to get things that they had totally overlooked.

In order to facilitate student exploration of the multimedia resource, the teachers gave a brief introduction outlining the design of the resource. They reviewed the menu items, zones, progression bar and help features. Roberta did this using a group teaching setting and displaying the introductory screen with a video projection system. Heather had the students gather around her computer and view a sample screen. Leslie and Suzanne gave an overview to students when they first signed on to the program. Heather used teacher direction in each class by getting students to find information that they shared with her and the class and that was written on class charts. Suzanne provided challenge questions based on the science SLEs and let her students determine their own strategies to find the answers. Student findings were discussed in a teacher led discussion during the closure portion of each lesson.

Teachers felt that, despite student interest in the CD-ROM, the learner objectives for the science program would not be effectively addressed unless the teacher imposed some structure on learning activities. Teacher direction was given which outlined expectations for each student for completion of assigned activities. Students were expected to demonstrate to the teacher that they were achieving the intended learning outcomes for the unit. Teachers monitored student progress and encouraged students to be accountable for completion of learning activities in the multimedia resource before students were given free time to explore the resource on their own.

Heather, Leslie and Roberta used similar approaches with both the Spider and the Bear CD-ROM. Heather, Roberta and Leslie felt that if student learning was to continue, they needed to have teacher controls on the students' progression through the Bear CD-ROM. Suzanne disagreed. Suzanne gave the Bear CD-ROM to the students and left it to each student to choose how to

proceed with the study of bears. She felt her students learned what she wanted them to from her teaching approach with the Bear CD-ROM and that teacher direction was neither necessary nor desirable. The other three teachers felt their students would not have progressed through the learning activities without continued teacher direction throughout the bear unit.

One possible explanation for the differences in viewpoint on the matter of teacher control of learning may stem from the different student populations in the classrooms. Midway in the project a student from Heather's class transferred to Suzanne's classroom as a result of the family changing residences. Suzanne discussed that the arrival of the student had caused some disruption in the classroom and had prompted Suzanne to make alterations in her teaching plans and investigate possibilities for alternative programming for the new student. Suzanne reported that the new student had experienced significant difficulty in settling into the classroom environment and that the student had difficulty working on the student directed learning activities that were a significant part of daily activities of students in Suzanne's class.

Seeking advice from Heather, Suzanne hoped to gain a better understanding of the new student. This discussion brought information to the group about the differences between the student populations in the two schools. Heather stated that the student was of average achievement and fit in well with the other students. In Suzanne's class, the student clearly was at the low end of the class and qualified for resource room intervention. When this matter was discussed during the fourth interview, the teachers suggested that the ability levels of the students and their experience in student directed learning environments influenced how the teachers would proceed with teaching.

> Lynne: The fact that your (Suzanne's) students eagerly chose computers as research tools over books may help to explain why you were the only teacher in our group that felt you could let you students do the Bear CD-ROM on their own.
>
> Heather: I felt that my kids would not do very much if I did not guide them. I believe that kids can get something out of multimedia on their own but they can get a whole lot more out of it when we guide them.

Suzanne had a greater number of students who were competent at grade three level reading skills, were very comfortable in working in a computer setting, and were experienced in student directed learning. Consequently, many of her students had better developed learning skills to work independently using the multimedia resource. Their confidence in their own learning was evident in their eagerness to pursue learning independently using the computer. Many students in the classrooms of Heather, Roberta and Leslie were not able to work independently and continued to be somewhat dependent on teacher direction.

Another possible explanation for the differences in Suzanne's approach to teaching could have been that her knowledge and experience with the new science program and technology use in her classroom influenced how she taught science. Her school district committee work on the implementation of the 1996 program of science studies provided her with confidence in teaching science and using technology.

Social Dimensions of Learning

Teachers discussed the social context of the classroom. Activities involving the interaction between students and between students and the teacher emerged as a significant consideration for teachers in the study. When the teachers spoke of the social dimensions to learning they referred to those activities in the classroom that involved student discussion with each other and the teacher, interaction with the other people in the classroom, group and partner work, field or lab work, and classroom discussions. At the beginning of the project, little discussion occurred about the social dimension of the classroom but as teachers proceeded through the unit of study the social components of learning were discussed at length. Some of the changes in teacher understanding of multimedia resources were initiated by their new insights into the social dimensions of student learning.

In the opening lessons of the unit, Leslie and Suzanne had students assigned to individual computers and each student was issued a Spider CD-ROM. A few of Suzanne's students made the choice to work in pairs and share a

CD-ROM while most students proceeded through introductory activities independently. Roberta, having access to five computers for 28 students, had to group students to work at computers in pairs or threes from the start of the unit. Heather had her students working in partners from the beginning of the unit despite having enough computers to give each student the opportunity to work independently. Within two weeks of beginning the unit, Leslie had changed her teaching approach and introduced learning activities with students in pairs or groups of three. Leslie made a conscious effort to add activities involving student interaction after observing independent learning and feeling uncomfortable with how her science unit was progressing. She said that when the students were engaged with the multimedia resource, the room was silent and the students were interacting with the multimedia resource but not with each other.

Each teacher incorporated the social components of learning in different ways. Heather paired her students and then circulated through the class while students worked on assigned portions of the CD-ROM. Nine pairs of students were progressing through the Spider CD-ROM in student chosen pathways.

> Lynne: So you pair your students at the computer? Does that seem to work ok?
>
> Heather: Yes, seems to work fine. I like it but it gets noisy.
>
> Lynne: Students chat with each other and interact about what is happening on the screen?
>
> Heather: Yes and it helps for later in the unit when I will get them to work independently taking notes. It helps to have two students in partners because one might be better at note taking than the other. They can help each other out.

Heather found that her students helped each other out in the operation of the computer and software. Heather found this useful because she did not feel confident about the operation of the computers. Roberta found that by having her students in pairs and threes that students played the role of teacher by asking questions of peers and providing assistance for progression through the CD-ROM. They also had to co-operate and work as a team. She left it up to

each group to determine who had control of the mouse and how the students would navigate through the CD-ROM.

Leslie struggled with the use of the multimedia resource and having her students more actively involved in interaction with each other:

> Leslie: Well I started with all my kids in the lab and each one on the computer with the Spider CD-ROM and I thought everything would be wonderful! But it bothered that it was so quiet and that the students were not talking to each other. There were no social skills happening. So when we got to the Bear CD-ROM I paired the kids up so that there would be more interaction with each other. Stop putting your face in that computer! I didn't like that. So I went the other way from having students on individual computers to having students work in pairs.
>
> Lynne: You said that at grade three ... the interaction of students is really important and that you try to incorporate it in some way.
>
> Leslie: Yes at times but depending on how competitive the kids get. When I gave them a challenge question: "What is bear's scat?" on the first day of the bear unit they really took it as a personal challenge and it was quiet in the lab. They were just stuck to the computer and I thought this is not what I want. But once a couple students came up to me and whispered the answer I repeated "bear poop" out loud, then the kids opened up and started talking to each other and sharing. That is more what I wanted to see.
>
> Lynne: So you want students verbalizing and discussing answers?
>
> Leslie: Yes I want to see more of it. It is too boring for science to be quiet. Science shouldn't be boring.
>
> Lynne: I wonder if they were totally engaged in the CD-ROM and that is why they were quiet and maybe they weren't bored at all. But that is not the way you would like to see science learned?
>
> Leslie: No.
>
> Lynne: So you see science as active? It is interesting when you have the wonderful computer lab setting, you don't like it when students are quiet ... . You actually intervened with comments to get students more talkative and social.
>
> Leslie: No, I don't like it when they are so quiet. I have added a question of the day where students have to find the answer and share it with the other students at the end of the class. I think that by putting them in pairs and letting them to propose questions for each other and other groups that I am helping them to think in a different way.

Roberta experienced this insight into incorporating social components in student learning:

> Roberta: I never used to be like that. I used to make students work independently. Now I see that noise can be very productive and that students learn better when they are having fun with each other. When kids interact the more confident learners also help the weak ones. Partners can be strong role models for weaker students. I think my need for control in the classroom diminished as I have come to understand more that kids can learn in a variety of environments.

Students in Suzanne's classroom were given the chance to work independently on the computer. However, Suzanne spoke in support of the importance of having students interact and communicate with others as part of student learning:

> Lynne: Would you teach all of your science on the computer if you could?
>
> Suzanne: No way. I like the computer and I like what it does but it takes away the human element. It takes off the hands on kind of thing. One thing that makes me sad is that when I talk to kids about what do they do after school they tell me they play on Nintendo or the computer. That really bugs me about the way kids are going because that's their kind of social interaction. I think the computer is an excellent tool that you can use in moderation.

As teachers progressed through the study and talked about their experiences, it was evident that teachers valued the social dimension of learning. This was evident in teacher encouragement for student to student and teacher to student interaction through discussion, peer teaching, solving problems and communication about what was being learned. They identified that, despite the engaging capability of the Zoology Zone multimedia resource that it was important to encourage students to interact with others in the classroom.

Student Directed Learning

The multimedia software, as the primary teaching resource, provided some benefits for students to take control of their learning. In recounting experiences with Zoology Zone multimedia resource, teachers had contributions to make about the role of the software in facilitating students to learn

independent of teacher direction. Teachers identified four features of the multimedia resource that encouraged student control: (a) motivational features, (b) reading level, (c) navigation structure, and (d) feedback and reinforcement.

Clearly, one of the motivational attributes of the software was the way students were drawn to the learning activities and were engaged throughout the duration of learning activities. The initial responses from all four classrooms were overwhelmingly positive. Students liked the software and were eager to utilize it as part of their science learning. Furthermore, teachers suggested that, due to students' motivation to use the multimedia resources that teachers should attempt to incorporate it into learning activities.

Excerpts from teacher interviews illustrate the motivational strengths of the Zoology Zone multimedia resource:

> Leslie: They students are very enthralled with the CD-ROM and they really enjoy it. There are certain parts of it that they are more in tune with than others. They like the games part. The tests where they are putting the spider together and those kinds of things they really like that. The stories are ok. They are talking about the different types of spiders, where they live and what they eat. They quite like that.
>
> Roberta: My kids are really keen about using the computers and anything associated with it. I like to capitalize on this interest. My students really liked the games in the Zoology Zone multimedia resource. Even my teacher assistant commented on that. He noticed that when his group finished assigned tasks they would go back and revisit games playing them again and again.
>
> Suzanne: My students quite enjoy the Zoology Zone multimedia resource and are so attracted to it. That's why I think that as teachers, you have to kind of keep going with it. I love things that it does – like all the bar graphs you can do. I like this Zoology Zone multimedia resource CD-ROM you have developed because I think that kids get really excited about this kind of thing.
>
> Heather: The kids like it. You say you are going to computers and they are happy. They like the games. The way the world is going these kids need to be ready. They need to feel comfortable and I guess that is a big part of it at this level. Feeling comfortable, turning the computer on, being able to work around and move around in the program, things like that. The kids really enjoy Zoology Zone. They certainly want to do it again. They keep asking: "Can we do it again?" It is very easy for the kids to move

from one place to another in the CD-ROM. They found it very easy to manoeuvre around and actually had no problems.

Roberta: The students really enjoy Zoology Zone. With the first demonstration they were saying things like: "Cool! Gross!" They really like the close up of the spider. It was worth using because the kids really loved it. As far as holding their attention -- all 28 kids were quite mesmerized by it. We probably did about a forty-minute introduction lesson and they continued to be interested in the lesson. They thoroughly enjoyed it.

Suzanne: The students really liked it. One student that is actually not emotional at all – I let him try it first. He was the only kid initially who got to try it on his own. The next day when we had all the computers going his eyes really it up and he actually showed some emotion and interest which was unusual and a good sign that it was a good thing! They loved the games of course.

In the field notes from my visit to Heather's classroom, I found additional support for student motivation encouraged by the multimedia resource:

The students enthusiastically responded to the teacher announcement that it was time to go to the lab and work on the Zoology Zone multimedia resource software. They quickly lined up, proceeded to the lab and hurried to computers, chatting merrily with each other as they opened the program and navigated to where they wanted to be on the CD-ROM. Throughout the class students were engaged in their learning activities, happy, smiling and eager to share with me what they were learning about. The teacher did not direct any student back to task during the one-hour visit to the computer lab.

The teachers discussed the features in the multimedia resource that assisted in keeping student interest high. When asked to describe the features of the multimedia resource that contributed to teacher satisfaction and that may have influenced students' initial captivation and subsequent engagement with the resource, teachers volunteered that the variety in learning activities appealed to students. Teachers said that the variety in the learning activities appealed to the many learning styles of students. Activities in the CD-ROM included reading, listening, and viewing video clips, games, self-tests expert accounts and observation. The collection of cartoon characters, use of student voices in narration, testimony of local experts, video clips of animals, search and find activities, screen hot spots, music, interactive games, and child humor were cited

by students as things they liked about the multimedia resource. Teachers said that the extensive variety in presentation appealed to the many different learning styles of their students.

Teachers discussed strong support for the appropriateness of the reading level for grade three students. This attribute of the multimedia resource surfaced in many discussions as a feature of the resource that could allow students to direct their own learning.

> Suzanne: That's why I think the Zoology Zone multimedia resource software will do so well. I don't think that there is a kid that is not going to be attracted to the kind of stuff on it. And thank goodness it is readable at their level!
>
> Heather: I found that when the kids were looking for information and pulling information from the Zoology Zone multimedia resource CD-ROM that is was at a nice level for them. I have done some work on the Internet with grade threes and the reading level is too high. Even when they can read it the comprehension is not good. Whereas with this CD-ROM they were pulling information out and they understood it. It allows them to work independently on it and I really like that.
>
> Leslie: When viewing the Zoology Zone multimedia resource the first thing I looked for was the vocabulary and level of reading and understanding.
>
> Heather: For sure reading level would be the first thing I would zero in on. Because even if the multimedia resource touches on everything I want to teach if they cannot read and understand it then I am just reading it to them and three is no point in using the resource.

The audio option provided students with the choice to read the screen text or to have it read by a narrator. This feature was cited by the teachers as very helpful in assisting weaker readers in progressing through the multimedia learning resource:

> Roberta: The reading level was a plus with this resource. And if the reading level of the student was below grade level – which is two thirds of my class – a lot of information was read to them. It was read and they could follow along which was really good because then the poorer readers were able to follow and keep up.

All teachers discussed concerns regarding reading level when they had previously carried out research projects on the Internet. One benefit of the

Zoology Zone multimedia resource was that it reduced problems created for the student learner when reading levels are too advanced. Heather's experience with Internet research activities and subsequently with Zoology Zone multimedia resource demonstrates this benefit of the multimedia:

> Heather: The thing is the kids put in the Zoology Zone multimedia resource CD-ROM and they are there. The information and activities are in front of them. I don't have to hear that "I am not in!" Or "I have been cut off!" As a teacher I am constantly running around fixing problems when I try to do something on the Internet. And the students don't understand a lot of what they have to read when they visit Internet sites.

The appropriateness of the reading level for the grade three students allowed teachers to let students assume control over a portion of their learning. At the same time, the appropriate reading level provided encouragement for students to take control of their learning.

The teachers said that it was easy for students to assume responsibility for their learning because they found it easy to navigate through the CD-ROM. Students found the multimedia resource simple to use. They were assisted through the help character, Ribbert, and through color coded zones of learning, flashing arrows to direct students to move through activities, and audio prompts for success and completion of activities. The design of pull down menus also provided students with the direction they required to effectively utilize the software.

Special features in the design of the multimedia resource provided audio and visual feedback to student users. These encouraged students to progress through and complete learning activities. The audio options for text, and praise and reinforcement prompts from the narrator provided students with assistance and encouragement.

Learning Distracters

In the study, teachers raised the concern that the multimedia resource could be distracting to student learning. There was evidence of some student frustration with the resource, unanticipated problems with student

comprehension, and a tendency by some students to focus on the multimedia resource to the exclusion of other resources.

Suzanne and Leslie said that when students tried to access Internet sites or when the CD-ROM did not load properly students became quickly frustrated and disappointed. The teachers agreed that when students do get frustrated they are less likely to revisit the same activity again. When some of Leslie's students accessed the Internet sites and found them under development, the students seemed disappointed. Two days later when students were informed that the sites were active, none of the students chose to return to the sites to check out the information.

Teachers had not anticipated some reading comprehension problems that surfaced. The issue of comprehension was raised several times by the teachers. As noted earlier one of benefits of the multimedia resource was the appropriate reading level. However, this advantage of the multimedia resource also pointed to a concern raised by Heather, Leslie and Roberta. These teachers found that, as they circulated around to their students checking on student understanding, some students did not fully comprehend the material. The students could articulate some of the answers because the content had been delivered through audio portions of the program but they did not fully understand what they were saying. Roberta said that in her class discussion, when she asked students what they meant by terms they had presented in the discussion (e.g., pedipalps and bear profile), students had not comprehended the meaning of the terms despite being able to use the terms appropriately in a discussion. In particular, as also noted by Heather, the weaker students relied on the audio scripts for their learning and had some difficulty when asked to read or reread the same material in a text format.

Teachers stated that the multimedia resource was one more tool to help the teacher teach and help the student learn. However, teachers were in agreement that multimedia resources should not be used in isolation from other teaching resources or strategies. This was in part because they did not have unlimited access to the computer lab and also because the teachers placed

value on the use of non-computer learning resources. All four teachers supplemented the Animal Life Cycle topic with other classroom-based activities. Other classes of animals were studied (e.g., amphibians and reptiles) with non-technology resources. Students were encouraged to use other resources to expand their knowledge of the concept of animal life cycles.

> Leslie: Kids have to learn to "sort" through their learning. They need to learn to get information from many sources and to synthesize it. It was interesting when the students had to do their research project how many of them asked first --- well where are the books? Even the kids who picked spiders as their research topic didn't go to the CD-ROM first for information. They went to the books that I had pulled for them.
>
> Lynne: So you advise other teachers that the CD-ROM is one tool for learning and you should not use it to the exclusion of other teaching and learning activities.
>
> Leslie: Yes, especially at the elementary level. At the primary level we are trying to get students to learn the basics – to read more, to locate information and to use it wisely. To have someone else do it for you on a CD-ROM –well they have to know that there are other places to look for information as well.

Teachers indicated that the attraction of multimedia could influence students to rely on the multimedia resource to the exclusion of other resources. Teachers felt that it was important to emphasize to students the role that multimedia resources have in learning and that they are one tool for learning and are best used in conjunction with other learning tools.

The findings of the study indicated that teachers felt that their students had learned from the multimedia resource. However, the achievement of each student was not examined as part of this study. The content and design of the multimedia resource provided students rich opportunity to explore on their own while the teacher assisted students when they needed help. The students were motivated by the multimedia learning resource and their attention was kept focussed on a wide variety of learning activities that appealed to many learning styles. The teacher facilitated learning through careful implementation of teacher directed activities as needed, supplying additional resources, and incorporating learning activities that encouraged interaction between the students and the

teacher. Despite a few distractions to student learning and the cautions that teachers identified in using the multimedia resource, teachers enthusiastically supported it as a resource that contributed to student learning.

Role of the Teacher

The use of a multimedia resource in a classroom has implications for the role of the teacher. In this research study, teacher participants identified variations in the role they served in a classroom when using the multimedia resource which differed from the role they felt they had in lessons not using multimedia resources. The teacher role is discussed as it relates to: (a) classroom management, (b) addressing curriculum expectations, (c) assessment, and (d) adapting teaching style.

Classroom Management

Adjustments were made in classroom management techniques to support the effective use of the multimedia resource. Roberta, due to limited computers and a large class had to utilize her teaching assistant and library resources and divide her students into two groups.

Heather and Leslie found it useful to partner students for learning activities. The felt that there were benefits by having the students proceed through the multimedia resource in pairs because they could share and discuss findings and experiences.

When students were in the computer lab working on the multimedia CD-ROM, teachers had to create opportunities for students to work on other non-computer activities. Heather and Suzanne had their student's work on the floor of the computer lab when they were doing games or written activities. Leslie and Roberta, because of placement of computers in the library, were able to let students do pencil and paper work at tables.

Teachers structured their lessons to make time to circulate to each student to check student comprehension and ensure on task behavior as they progressed through the CD-ROM.

When students worked in groups, teachers let students determine how they would progress through the CD-ROM and to agree on a process for sharing control of the mouse.

One other classroom management concern related to the placement of computers and use of headphones. When the new lab of 30 IMACs arrived at Roberta's school, the new computers were crowded into the spaces that 15 computers had previously occupied.

> Roberta: It is very crowded – it was so tight that it was better to have students only assigned to every other computer so that the kids could stay focussed on what was on their computer. It was hard for them to stay on track with so much else going on so close around them. The computers were literally touching one another.
>
> Suzanne: I find when one of my students uses the classroom computer it is distracting to other students at their desk in the classroom. When one kid is on the computer, of course, everyone is attracted to it. When they can all see the computer screen they don't concentrate on what they are supposed to be doing at their desks. I might think about turning the monitors so they are facing the other way because it is such a distraction to the students who are looking at the computer when they should be working on their assignment.

The issue of headphone availability was a concern discussed part way through the research project. Leslie had access to headphones for each student. Roberta experienced concerns with noise levels in the library based computer lab but due to head lice concerns in the school was not permitted to have students use headphones. Heather and Suzanne did not have opportunity to use headphones but discussed some interest in pursuing the possibility at a later date.

> Roberta: Also, the computers in our lab are literally touching one another – what we really need are headphones as the distraction is so great between computers. And the problem with headphones is that we can't use them because of head lice. We are trying to brainstorm some ideas to get cheap headphones that the kids could buy for themselves. I saw some in the dollar store last week but don't know whether they would fall apart right away.
>
> Suzanne: What about contacting an airline – they know where to get cheap ones.

Roberta: That was another possibility – they can't be spending a ton of money on those. The problem would be would they last. But maybe we could include it in the school supply list?

A consideration discussed by the teachers was the demands of time that the multimedia resource created for student learning. When using more traditional resources such as books and pictures, the teachers could plan to carry out all learning activities in their classroom and had flexibility to use the resources at any time of the day. In order to ensure students learned from the multimedia resource they needed sufficient blocks of time in the computer lab setting. These time blocks had to be booked in advance and were limited because of the demands by other teachers in the school to utilize the computer lab. There were also incidences when student computer time was cut short due to unexpected interruptions in the school schedule, computer problems in the lab, or changes made to the daily plans of the teacher. Teachers identified these instances as problematic for classroom management.

Curriculum Expectations

Discussion regarding teacher responsibility to the Alberta curriculum centered on the science program of study and the ICT outcomes document. Teachers offered their perceptions on the teacher expectations set out in the two curriculum documents.

The ICT outcomes document outlined technology expectations for integration of technology into the school program but did not assigned specific skills to specific grades. Reference to the document led to a discussion on the role of the Zoology Zone multimedia resource in technology learning and brought mixed feelings from teacher participants. All four teachers agreed that Zoology Zone multimedia resource was a fine resource and that it had a place in the classroom. The debate centred on the more general question of expectations by school administration, Alberta Learning and the general public to integrate technology at all grades. Teachers were questioned about the direction from Alberta Learning to implement the ICT outcomes in grade three. Their reactions below point to some challenges of technology learning at grade three:

Suzanne: Sometimes I think we expect too much out of grade three kids. Sometimes we put too much emphasis on technology. If you look at keyboarding, for example – the kids hate it. It is hard for them. I just don't think that they are there yet. Maybe the top kids can handle it but I don't know. I hate doing keyboarding with them yet they want to be at the computers. I think with programs like Zoology Zone that technology is better for kids—I want to do more of that kind of thing.

Leslie: I sit on the technology committee for our school and we talked yesterday that the technology goals for Division One were unrealistic because there was far too much emphasis on computer skills. These kids need to be cutting and pasting paper, not cutting and pasting on the computer, because they use more limited areas of the brain that are actually DOING these things. So I am looking (and the committee) at limiting some of the technology expectations.

Lynne: So your assessment in your school is that more implementation of technology at grade three is NOT desirable?

Leslie: Too elaborate maybe. Too many of them –too many ICT outcomes. In some of our software programs students go to them and they need to know how to type, how to do word processing and yet these are not Division One skills but they can't use the software if they don't apply those skills. So then we are tending to push the students into uncomfortable areas in the computer lab when we wouldn't do this in the regular classroom. I mean if you go to a lab and find a whole bunch of kindergarten kids sitting there with headsets on and their face stuck in a black box, looking at a computer screen? That is not what kindergarten should be. They should be playing, and doing and touching...

Early in the research project, two of the teachers suggested they might utilize the Zoology Zone multimedia resource as a model for students to develop their own science multimedia presentations. The potential existed in the four participating schools for students to use presentation software. However, by the end of the unit none of the four teachers felt that it was reasonable to get students to develop a multimedia presentation:

Roberta: In social studies, I started a project on the Olympics in which students had to create sport cards using a database. They took information from a Calgary newspaper because when they tried to take information from the Internet it was too difficult to read and often too detailed. It took so much time and effort because of their weak keyboarding skills, poor reading ability and need for

teacher direction that I finally had them finish the project by hand drawing pictures on the computer generated sports cards.

Leslie: I considered having the kids do something with a technology presentation but decided it was tool difficult for them. I don't think grade three should be spending time making multimedia projects. Perhaps by grade five but it is too difficult for primary students.

The Zoology Zone multimedia resource was limited in the provision of authentic experiences students could have with live animal specimens. Animals were illustrated in slide or video formats. Leslie summed up the implications of this limitation of multimedia in science:

Lynne: Would you do the Animal Life Cycle topic differently with books and classroom materials than you have with the CD-ROM?

Leslie: I wouldn't do it any different with books. In the Animal Life Cycle topic you rely a lot more on books, computers, Internet and what ever for your information because it is difficult to get student to actually experience the concepts in the unit. Like I am not going to go and get a frog when we are discussing frogs. Sometimes it is okay. We had spiders in here all over the floor but we have had difficulty trying to keep animals alive in this school. So using videos on the CD-ROM works fine. It might even help this unit a bit.

Teacher reactions indicated that the learning expectations in the Animal Life Cycle topic could be achieved without the extent of hands on activity in the classroom that many of the other science units would require (e.g., rocks and minerals, hearing and sound). Due to nature of the unit, the teacher participants viewed multimedia portrayals of animals as helpful and effective.

The teachers' attitudes regarding multimedia as one of many tools for learning were evident in the additional resources that the teachers made available to students to supplement the CD-ROM multimedia resources. When student questions came up, the teacher and/or the class would seek answers. When the answers were not provided in the CD-ROM, teachers directed students to find the answer in alternate resources. Leslie and Suzanne had some students search the Internet for answers. Reference books were also provided as sources for answers for some of students. Suzanne encouraged her students to evaluate the CD-ROM as a research tool in attempts to teach them to be

critical learners and to be on the lookout for related information in other resources.

> Suzanne: I also think that not only do students view the CD-ROM as a tool but my kids have also learned that they have to evaluate the tools they use. They may come up with an example from the CD-ROM – like spiders lay 100 eggs a day. Then they may see the same information contradicted in a book that says they lay 50 a day. I have to help them learn to be critical readers.

The teachers determined what they would teach in the unit from the guidelines discussed in the science program of studies. They felt responsible for completing the SLEs identified for the Animal Life Cycle topic. They also believed that there were many strategies they could implement to best address the curriculum expectations including planning of a variety of learning activities and giving students opportunity to learn from a variety of resources and from integration of subject matter into other learning. The technology outcomes as outlined in the ICT program of studies were a less important priority for the teachers. They discussed interest in having the students utilize technology in the learning of science but were not specific in what ICT outcomes they intended to address in the unit.

Student Assessment

On matters of student assessment, Roberta, Heather and Leslie felt that their students learned more by having teacher directed portions of both the spider and bear unit in which students had to be accountable for what they were learning by demonstrating what they had learned in written assignments. Heather and Leslie both kept checklists documenting the progress of each student through assigned learning activities. Roberta discussed with her teacher assistant the progress of students on each learning activity in the multimedia resource. These teachers felt that it was preferable to exert some controls on the progression of students. Suzanne, leaving the students to choose how to study the Bear CD-ROM, disagreed. Her feeling was that as a teacher you never really control the student learning and that benefits are gained by letting students take control of the learning. She felt her students learned what she wanted them to

from the Bear CD-ROM without specific teacher direction. She expected her students to apply what they learned in the spider study to their self guided study bears. The other three teachers felt their students would not have progressed through the learning activities without teacher direction.

The teachers discussed their role in ensuring that students were accountable for their learning. This was achieved in various ways including teacher questioning, classroom discussions and completion of assignments related to the learning activities on the CD-ROM. Roberta asked her students questions and asked them to explain their responses. She also asked them to write in journals and contribute to putting information on classroom charts. Each student also had to complete an animal research booklet and a personal journal. Heather modelled note taking throughout the spider unit and then had students do the same activity when they studied bears. She kept detailed records on which learning activities each student had finished. A checklist of expectations was compiled for each student. Leslie monitored each student each class, checking the site map on the CD-ROM and the screen progression bars to determine the progression of the students through the learning activities. Suzanne tested for understanding by having the class complete the workshops as a large group and by having students complete various written assignments documenting what they had learned. The teachers said that they wanted assurance that the students were learning something so they implemented various activities in which students demonstrated accountability for their learning.

> Heather: I felt that I needed to know what they were doing. I needed to have these sheets (class charts of animal information) with questions so that I knew that they had been to every zone and touched on everything that I wanted them to in the unit. Otherwise, they might just not do much. They need teacher direction.
>
> Suzanne: And that is why I think teachers are SO important. If you just put students in front of the computer you can't be guaranteed anything. That is why I think virtual schools are [pointing thumbs down] not a good thing!
>
> (Agreement from others)

Leslie: I also think that students are not building and bringing other ways to learn to the classroom. That is the whole idea of us as teachers being there.

Heather: I believe that the kids can get something out of multimedia but they get a whole lot more if we guide them.

Leslie: I would give my kids the question of the day and they would go on and do that and then go on to other areas of interest. But at discussion time at the end of the class they would tell me what they learned. And even with that I may have half of my kids sit there and they may not be sure what they did learn. They may say things like, "Where did you find that?"

Teacher participants agreed that they had a significant role to play in the classroom in encouraging students to be accountable for their learning. Despite the attraction of students to the multimedia resource, students required direction to demonstrate what they had gained from various learning activities. The teacher also was instrumental in providing students opportunities to demonstrate that they could apply learning from the multimedia experience to their personal lives.

Adapting Teaching Style

All four teachers agreed that they shifted between teacher-as-facilitating and teacher-as-directing. They viewed their style as teacher as facilitator when students were captivated by the resource and the teachers were freed up to move about the classroom, observing students and interacting with them. The teachers said that they assisted students in dealing with emergent technical problems. Teachers also facilitated learning by answering student questions, redirecting individual students to task if they became side tracked, and supporting students in their enthusiasm when they discovered something of interest that they wanted to share. The teachers posed challenging questions to get students focussed on exploration through the CD-ROM. Suzanne had a question of the day. Leslie borrowed this idea and implemented it. Heather posed several questions each class and had students search for answers and share their responses. Roberta incorporated questions on content of the CD-ROM to check student understanding and to keep interest levels high.

At intervals during the teaching of the unit, all four teachers assumed teaching styles that were predominantly teacher directed. In the Spider CD-ROM all four teachers directed students to apply and synthesize what they had learned from using the multimedia CD-ROM. During question periods and discussions at the end of science classes, teachers invited students to share their learning. Students were encouraged to apply their learning to real life experiences (e.g., observing a spider spinning a web). Stories about encounters with spiders enriched learning as new information was presented to students through their exploration of the CD-ROM. Heather asked students add information to classroom charts and integrate learning in a language arts writing assignment. Suzanne co-ordinated classroom discussions on the topics of study. Roberta and Leslie invited students to share their personal experiences during small group and class discussions. These activities were primarily teacher directed learning activities.

The teacher had to make choices about balancing which type of teaching approach to use and when. Teachers discussed that they found student directed learning to be very effective but they also said that they had a responsibility to ensure that the curriculum was taught in the time allotted. The pressure of achievement tests was also a consideration for the teachers. These factors contributed to a shifting between teacher directed learning and student directed learning. The constraints placed on students to complete assigned activities and progress through the unit were necessary to ensure that the class completed the unit in the time allotted regardless of how successful teachers felt students were being with their learning.

Teacher Learning

The Zoology Zone multimedia resource was an unfamiliar resource for all teacher participants in the study. Throughout the study, the participants developed new understandings about multimedia resources. Their personal learning experiences, as they journeyed through the Zoology Zone multimedia resource as part of the Animal Life Cycle science unit with their students,

uncovers a variety of understandings about teacher views of learning and multimedia.

Teacher Views on Teacher Learning

Teachers agreed that they had grown professionally in their knowledge about use of multimedia resources in the classroom. Teachers said that they had learned in different ways from participation the research project. They learned from each other, from the researcher, and from their own experiences with their students as they journeyed through the research project. Part of their motivation for joining in the project, cited early in the project, was that the design of the research created, scheduled, and facilitated opportunities to meet as a group and discuss progress with the Zoology Zone multimedia resource.

The teachers learned from their students. The teachers said that students would bring up questions about bears or spiders and if the teacher did not know the answer the teacher directed the students to find it from another source. Students would go back to the CD-ROM, search the Internet or available books, or contact other adults for increased understanding. Students also provided assistance to teachers in operation of the software and in solving some of the technical issues. Teachers said that students discovered short cuts and identified many of the special effects included in the multimedia resource. The teachers said that there were many occasions when the students taught the teacher about software specifics or the location of information in the CD-ROM.

The attitudes each teacher held about teacher learning influenced the value of the project for each teacher. During the closing group interview, the four teachers reflected on what they had learned as a result of the participating in the project. The teachers willingly shared personal accounts of their experiences as teacher leaders in their classrooms and as lifelong learners in their profession:

> Leslie: I believe that learning is a constantly ongoing process.
>
> Suzanne: That you yourself must be a lifelong learner. You want to model that for your kids and instil it in them.
>
> Leslie: That you will never get to the end.
>
> Heather: There is always something new you can add.

Leslie: You can always teach an old dog new tricks!

Various responses: Always! That's good!

Suzanne: And I think as a teacher you have to pull every trick out of the book to appeal to as many kids as possible. That is your job as a teacher. It is applying multiple intelligence theory.

Lynne: And multimedia gives you one more way to do that. (Agreement)

Roberta: One more thing that the teacher can use to grab one more kid.

Lynne: You told us that there were some kids who found both CD-ROMs more appealing than other kid(s) in the class -- that there was variance in the way the students responded to the media. (Agreement)

Suzanne: And you never really arrive. Learning is life long and you never really arrive. I like telling my kids how long I have gone to school. Because I think it is important for them to know that I love learning and that I read and other kinds of stuff. Sometimes they look at you like you're nuts but I think that means something to them. I really do. I think it is good for them to know how long people are committed to study.

The four teachers volunteered that they had learned about multimedia technology as an outcome of participation in the study:

Leslie: I am certainly a bit more advanced with technology. Also, spiders are not an animal I have ever focussed on before. So, I have learned about spiders.

Heather: For me it would be the technology. I mean I had never used a CD-ROM before so this was new to me. Right off the bat I have learned something. I can get it in and get it out (not so easy in my school!).

Leslie: And far as the ICT goes – I didn't know them before and I now I know something about them. This really got me going on them. It forced me to get into it right away rather than waiting or slowing proceeding ahead with them.

Lynne: You feel now that you could talk to your student teacher confidently about ICT outcomes and integrating them with science.

Leslie: Yes. And I certainly couldn't have before. I am not sure how great a job I could do now. But I am getting there.

Roberta: Probably I would agree with Leslie – I have a better understanding of the ICT outcomes. I felt that as far as using the CD-ROMs and technology I already had a pretty good grasp on that

and didn't learn anything new there. But I learned more what was expected in the classroom with ICT.

Lynne: What about the concept of multimedia resources? Did you change your understanding of that as a result of this project?

Suzanne: Yes – especially after you defined it.

Leslie: Yes – I was going to say that too – that once I knew the definition I have a better understanding and realize that I have been using some multimedia all along. I never really thought about CD-ROMs as being multimedia.

Lynne: You understand how multimedia is different than using the computer as a word processor or specifically for spreadsheet abilities. Multimedia is a combination of activities including text, audio, graphics and possibly more.

Leslie: I think multimedia can change some of the things you do in the classroom. I used to think that I liked the class quiet. But with this project when they were all quiet I didn't like it. Like my science class is never quiet – kids are talking and moving around. There is lots of interaction going on. When they were all on their own at their computer with their headsets on I figured I was set. Then, after a bit I was bored to tears.

Suzanne: I think there is a real business opportunity here for somebody.

Leslie: Yes – I had the grade three French immersion teacher come through and they wanted to have spiders and the grade one class wants bears. Everybody wants in on the CD-ROMs.

Leslie: In regards to being a critical evaluator of multimedia the first thing I would do would be to assess the vocabulary and level of reading and understanding.

Lynne: Reading level would be the first thing you would zero in on.

(All nod heads in agreement)

Heather: For sure, because even if it touches on everything you want to teach, if they cannot read and understand it then you are just reading it to them and there is no point in using the resource.

Roberta: Yes – like so many of the Internet sites.

Leslie: It can be a waste of time.

Roberta: Exactly – especially for grade three. And there is not a whole lot out there for grades three.

Heather: And the idea is for kids to work on it somewhat independently.

Lynne: Several of you brought up what Roberta was just saying with experience with Internet. You said that students are enthused about Internet but that it is a tremendous amount of work for the teacher to try to sort through and help kids with first of all doing the searches because key words are a difficult concept. Secondly the assistance kids need to know to navigate through the material to extract the information they need.

Leslie: Like when my kids went on the Internet. They got so frustrated. They put in the words spider Webs. But 'webs' got them web sites and web everything and nothing to do with spiders.

Suzanne: I think it is too much for grade three. Internet use is way above their heads. That is why this resource is so good. It is very manageable.

Heather: Actually I am dropping what I have done with the Internet before because of this project. I used to get the kids on the Internet – like in Social Studies when we would look at the Polar Bear. There is a good site at Sea World. It touches on everything but once again the reading level is too high. So I had parents come in to help kids through it. I am not doing it now because we have done bears with this CD-ROM. I am quite happy. This works better.

These findings demonstrate that the four teachers learned about multimedia technology and about strategies for teaching using multimedia resources (e.g., adequate planning involved depending on others in the school; students worked well in small groups). They also reflected on previous experiences with teaching technology and arrived at some decisions as to how they would proceed in the future with technology based teaching activities.

Puzzles in the Data

My interpretation of data took an unexpected turn with new data that I acquired during the final individual interview. As noted earlier, there were findings regarding the science education dimension of the project that were puzzling. In particular, when teachers referred to the SLEs from the Alberta Elementary Program of Studies, there was consistency in the value they attached to following the prescribed curriculum. However, my analysis of the transcripts pointed to obvious omissions regarding the SLEs for the development of science attitudes and science inquiry skills. Yet, as a researcher, I observed

teachers encouraging the development of science inquiry skills (e.g., students completing Explorations, class discussions). The puzzle that emerged could be summarized by the following question: "What do the teachers mean when they use the term SLE?"

I wrestled with what I thought was the participants' unspoken interpretation of the science program of studies. I needed clarification so I met again with each participant and uncovered some new meanings. These new understandings were important in the findings that I arrived at for the research study.

The timing for the fourth individual interview with the candidates is noteworthy. I had developed a very positive relationship with the four teacher participants. They were trusting of me and quite interested in the progress of the research study. They had also been recognized in their schools as taking a leadership role in technology and science by being volunteers in the research study. I believe the strength of our relationship contributed to their frank contributions during the final individual interview. Two of the participants were not comfortable with having their comments identified. Respecting this wish I have grouped the feedback from all four teachers.

At the interview I distributed a handout that included a summary of the teaching activities of each teacher during the teaching of the Animal Life Cycle topic. I also included observations and comments I had made regarding each teachers' experience with the Zoology Zone multimedia resource. Each teacher also received a copy of the SLEs for the grade three science program including the SLEs for Attitudes, Science Inquiry Skills and Understandings, and the Overview for the unit. After reviewing the summary sheet and getting clarification from each teacher on their experiences in the research project, I asked each participant the following question:

> "Throughout the research project you spoke about SLEs many times. Could you show me in this handout what you were referring to when you used the term SLEs?"

Each teacher paged through the five page handout and pointed to the SLEs for the Understandings from the science program of studies. When I

pointed out the SLEs identified on the other pages of the handout, the participants volunteered many comments. The highlights from these conversations follow:

> What? Those are in the program of studies? It is not something I remember seeing before. How long have they been there?
>
> That's amusing! I guess I haven't paid much attention to that portion of the science program of studies. I think I do teach a fair bit of that but I sure don't plan for it.
>
> Well, that's not surprising. Of course, the first place I go is to the content. That is where most of teaching time goes. I have to complete it all and I suppose if there was time to do more I might address the science inquiry skills more systematically. But there never is time. It is all you can do to get through the content. And if you don't, your principal and the teacher who gets the students next year is all over you.
>
> I have attended every science in-service in the past four years. I can't recall any discussion on attitudes or science inquiry skills. I guess I focus on teaching the content and using all the good stuff I get from all the professional development activities.
>
> Now, that I look more closely at the curriculum I can see that I do meet many of the overall objectives. I guess I feel confident that there is a certain way to teach science that is hands on and involves lots of student activity. I really have not thought specifically how to teach using constructivism or science inquiry.

It became clear to me that the first priority of the teachers was the content expectations in the science unit. It was also apparent that the teachers were familiar with only a part of the Alberta Elementary Science Program of Studies.

I questioned the teachers further about how they felt they met the attitude and science inquiry skill expectations in the unit, and how they approached the teaching of science in general. They stated that:

> By using an active teaching approach, students do engage in discussion and inquiry. When I ask questions and encourage them to ask their own questions, they are doing inquiry. However, I do not plan this. It just happens. And lots of times it doesn't happen.
>
> I have used the [KWL] approach a few times in the past few years. That involves getting the students at the beginning of the study of a concept to tell the class what they know about the topic, what they would like to know and what they will go and find out about. It works alright but it takes so much time that it is not really practical.

> I cover science all year long. So when events happen that I can use as a teachable moment, I do. These are the occasions when students are involved in science inquiry. I also integrate learning across several subject areas. This approach provides opportunities for inquiry as well.

I asked the teachers about providing opportunities for student-directed learning by having students develop their own questions and determine their own scientific inquiry. The teachers responses were:

> That sounds good on paper but is so impractical in my classroom. Most of my time is focussed on teaching students how to read and write. They lack the experiences and the language to define their experiences. This makes it difficult for them to frame questions that are appropriate for them to inquire further. As the year progresses they get better at it, but it is a gradual process and one that I lose track of. There are so many other things to do.

> I would love to use more constructivist approaches in my science teaching. It works best with small groups of students and it takes time. With a full class of students and achievement tests, the reality is that I don't teach science after mid May. None of the grade three teachers here do. They spend most of May and June preparing students for those tests. If you are even going to come close to covering the content of five units in science, you have to speed along. Most years I don't finish. If I took more time on any one unit, I wouldn't get through half of the curriculum.

> You have to teach them how to ask questions. They have a lot of problem with this.

> The other thing besides lack of time is lack of resources. Carrying out a science inquiry is a super idea but when you have a limited supply of materials to do so the task becomes complicated. I have one box of supplies for the rocks and minerals unit and a whole class of students needs to use it at the same time. That does not work too well. If I had ample resources, it would be very helpful to teach science the way it should be taught.

These findings illustrated that the teachers wrestled with challenges that made it difficult for them to teach science in a manner that encouraged science inquiry. Teachers also experienced challenges in using constructivist teaching approaches.

Chapter Summary

The experiences of each teacher in using the Zoology Zone multimedia resource contributed to understanding the research problem and addressed the research questions for the study. The findings presented in four categories discussed above, illustrate the experiences of teacher participants in using the Zoology Zone multimedia resource in teaching the Animal Life Cycle science unit. These findings point to the discussion I have developed about the relationship of constructivist teaching theory and multimedia technology as they relate to the teaching of elementary science. A discussion of these findings follows in Chapter Six.

CHAPTER SIX
DISCUSSION OF FINDINGS

Introduction

I will discuss the findings that resulted from analysis of the data by reviewing the research questions that guided this study.

Review of Research Questions

The study unfolded as each teacher participant used the Zoology Zone multimedia resource in the animal cycle science unit. Each teacher experienced the use of the multimedia resource differently. Through inquiry, reflection and discussion with other participants in the research study, each teacher constructed meaning from the multimedia teaching experiences. In my role as researcher, I listened to the participants, participated in the sharing of experiences, and observed them in their teaching environments. My involvement provided me opportunity to reflect on the shared experiences and to construct understandings in the three dimensions of this study: (a) technology as a teaching resource, (b) science education and constructivism, and (c) teacher learning.

Technology as a Teaching Resource

The research questions that guided this dimension of the study were:

1. What do teachers bring to the teaching experience that they identify as helpful skills, knowledge and attitudes when using the Zoology Zone multimedia resource?
2. What do teachers identify as useful in the use of the Zoology Zone multimedia resource in the teaching of grade three science?
3. What are teacher views about student learning and multimedia?

The teachers brought to the study an understanding of their students and experience with teaching strategies and teaching resources for instruction of grade three students. These understandings assisted the teachers in developing

teaching plans for using the Zoology Zone multimedia resource and assessing their experiences with it.

Teachers found that the multimedia resource assisted student learning. Most notable were the motivational effects for students. Teachers observed that the resource motivated students, capturing their enthusiasm and interest, and allowed them to pursue their own learning. The teachers were unwavering in their opinion that the multimedia resource had tremendous appeal to young learners. The immediate feedback, flexibility for use by the student, audio and video elements, hyperlinks to the Internet, and interactive components were highly engaging for students. The multimedia features allowed students freedom to learn in a variety of ways in which students controlled their own learning and this independence appealed to the students. It kept their attention, was fun, and provided a variety of learning activities that were highly visual and dynamic (e.g. animations) and provided students opportunity to navigate through activities in any order. The reading level of the resource was celebrated as the most appreciated positive feature because nearly all students were able to comprehend the information presented. They could conveniently revisit activities for reinforcement or enjoyment. Pupils viewed the resource as a modern way of learning and enjoyed having some control over their pace of learning. Teachers observed that students had increased confidence both in the science topics of study and in the use of the computer technology as the unit progressed.

The teachers brought to the study an understanding of the importance of the social dimensions of learning in a classroom. An appreciation for the personalization of science teaching was supported in the various activities teachers coordinated to support the social context of learning. The teachers indicated there were benefits for learning when teachers created opportunities for students to work co operatively and when the class collaborated on learning activities. Three of the teachers had students consistently work in small groups and pairs, and Suzanne utilized regular group and class discussions. Despite the possibilities for students to work independently and to be silently engaged

with the computer program, the teachers felt that learning environments in which students shared their learning with each other and the teacher were more productive for student learning. In this study, these understandings of learning theory were reflected in the various classroom management strategies implemented by the science teachers. Students were organized in pairs and in threes to carry out exploration of the multimedia resource and to address challenges posed by the teacher in assigned learning activities. The use of classroom discussions also assisted students in constructing meaning of science concepts by hearing the questions and feedback of other students. Appreciation for productive noise in the classroom supported teacher plans to have students work in small groups on assigned activities and to engage in independent exploration of the resource.

Teachers included some constructivist pedagogy in their teaching approaches to technology. They encouraged students explore and to solve problems as they arose. However, the students were in a situation in which the computer also initiated problems for the students to solve. These were caused by technical complexities with the CD-ROM and also by the random generation of questions in the learning games in the multimedia resource.

Teachers in the study said that they depended heavily on others for technical support. They brought to the study some frustration with technology, based on past experiences with technology that had failed. Previous problems with software and hardware access to computers and an absence of on going technical support all contributed to the teachers' somewhat cautious approaches to embracing technology integration. Teachers relied on support to ensure that appropriate facilities and equipment were readily available as needed by the teacher and that technical assistance was accessible as needed. Teachers also cited the need to be shown how to use the hardware and the multimedia resource prior to use of the resource in the classroom. In this study they received the support they required which was more technical support than they had received for other technology-based teaching endeavours. They said that they appreciated the technical support made available to them through their

school, through district support systems and through me in co-operation with the technical producers of the Zoology Zone multimedia resource. All teachers noted that they would be encouraged to utilize computer technology more if the level of support they received during the research study was consistently available for them.

The multimedia resource provided differentiation in learning and appealed to all students. It provided enrichment and learning extension opportunities for the more able students, while supporting the weaker students with repetition features and audio assistance in the reading of text passages. The animation and video sequences permitted students to see the animals in action and to see inside the animals. One example of this feature was the animated growth scale, which compared the life cycle of a child and a bear. These were demonstration components that would not be possible with non computer-based teaching resources. The teaching of concepts (e.g., identifying stages of the spider and bear life cycle) through the interactive games provided students with challenges to apply new learning and to develop understanding in a 'fun' way. Teachers observed that students learned about animal cycles and were enjoying the learning activities but were not specifically aware that the games were instrumental in teaching about life cycles.

The teachers found that students needed some guidance and direction when using the multimedia resource. Exploration had an important role in student learning. However, the role of the teacher was equally important in providing sufficient direction and guidance to student learners. The teachers took responsibility to provide challenges that assisted students in progressing through learning activities and provided encouragement to students by challenging their findings and by having students explain their findings and apply them to other experiences. Teachers viewed learning as an active process and agreed that students benefited when they were actively engaged in learning in which they made connections between past experiences and new learning. Active learning informed new understanding.

When the learning activities had relevance to the life of the student, they began to see the relevance of curriculum to their lives. The multimedia resource was rich in information but the teachers said that it was important that teachers ensured that students applied that information to personal experiences to construct relevant meaning related to the concept being studied. The teachers attempted to extend learning from the Zoology Zone multimedia resource by directing students to carry out a variety of follow up activities including completion of journals, worksheets and assignments, posing questions to other students, and asking students to share viewpoints and questions with the whole class. The teacher's role in coaching students to think, clarify and explain their reasoning assisted the students in constructing meaning from the learning activities. Teachers found that they had to monitor students to test for comprehension. Some of the weaker readers relied on the audio presentation of information and despite being able to verbalize their learning, some students lacked an understanding of the phenomena being studied.

The teachers found that the multimedia resource, used properly, provided freedom for the teacher to act as guide and tutor for student learners. Given the high levels of student engagement with the multimedia resource, the teacher was afforded opportunity to circulate among students and assist them in comprehension, interpretation and development of new understandings. Teachers also witnessed the different ways in which the students chose to learn and consequently benefited by gaining a better understanding of each student. Once again, as was true with student exploration, it was the appropriateness of the Zoology Zone multimedia resource that engaged students, making it more convenient for teachers to act as facilitators. A multimedia resource that did not have the features that permitted students to easily navigate through the software would not have supported a classroom environment where the teacher could serve as a learning facilitator.

The teachers emphasized the importance of being very familiar with the program of studies before implementing a multimedia resource. They felt that their experience with teaching the science curriculum gave them an essential

understanding of the prescribed science SLEs and assisted them in guiding students through learning activities with the Zoology Zone multimedia resource. Due to teaching experience with the science unit, the teachers knew when to direct students to other learning activities to consolidate learning of the objectives for the unit. Their teaching experience also helped them to appreciate the many different ways in which students might arrive at an understanding of a concept and to encourage students to pursue learning in different ways. The teachers said that teachers who were new to an instructional unit should be cautioned that the bells and whistles in multimedia, although engaging for students can also distract both students and teachers from the learning that is prescribed by the program of studies. The teachers' comments illustrate that they were confident in their understanding of the science curriculum despite findings at the end of the study which showed some limitations in their understanding. In regards to the ICT outcomes the teachers did not plan for or assess student success with the prescribed Division One learning outcomes. However, most of the Division One (i.e., K-3) ICT outcomes were achieved as a result of the use student use of the Zoology Zone multimedia resource.

Science Education

The research questions which guided this dimension of the research study were:

1. How do teachers view multimedia use in science learning by students?
2. What are teacher beliefs about technology and science education?

The four teacher participants, as a result of their experiences with the Zoology Zone multimedia resource, were supportive of the idea that multimedia resources have a legitimate place in the elementary science classroom. However, the teachers pointed out that the role of multimedia resources in the science classroom must be carefully monitored. Teachers suggested that it was necessary to be attentive to the prescribed curriculum and that it was their

responsibility to plan lessons that would facilitate the most effective use of the multimedia resource while addressing the program of science education as outlined in the mandatory Alberta curriculum. This observation illustrated the beliefs the teachers had about their responsibility for science teaching and science learning and these beliefs influenced the way in which the teachers taught the Animal Life Cycle topic.

Teachers viewed science education as one of many programs of study that they were mandated to teach. They planned instruction which addressed student learner expectations in each prescribed unit of study. The program of studies was the focus document outlining the parameters of what students must learn in the grade three science program. They believed that children have a natural curiosity about their surroundings and that the science program provides a framework for students to focus on the world around them, to explore and investigate to learn more, and to reflect and interpret meaning from new experiences.

The teachers concluded that multimedia resources could be one tool for student learning of science within the context of the prescribed program. Multimedia resources, when used appropriately, could provide students with rich opportunity to meet the identified outcomes in the science program. Teachers, once confident that there was expert content in the multimedia resource, could encourage students to explore and investigate the multimedia resource in search of meaning on animal life cycles. The flexibility in the multimedia resource allowed students to investigate the unit of study in many ways. They could select their own learning pathways and they had freedom to determine the order of learning and the amount of time to be spent on various learning activities. This was a particular strength of the multimedia resource in that students had considerable freedom to construct meaning using a variety of pathways through the multimedia resource. When teachers posed challenges to students that sparked their curiosity, the students eagerly explored the multimedia resource investigating possible solutions that would assist them in constructing meaning about various dimensions of the study of animal life cycles. Once students were

comfortable with the navigation through the resource, teachers were confident that, with guidance, students could learn with the multimedia resource. Critical to this end was the belief that student exploration of the multimedia resource must be supported and encouraged by the teacher.

Teaching approaches that encourage student exploration, as described above, are not unlike approaches teachers would use with non computer teaching resources. However, the convenience of the Zoology Zone multimedia resource facilitated student exploration. Initial exploration of the resource was a classroom management strategy to capitalize on student enthusiasm for a new learning resource and to familiarize students with the full resource. This strategy helped to reduce off-task behavior when the teachers required the attention of students to move to specific uses of the resource as directed by the teacher. The four teachers used similar approaches when new textbooks were issued to students for first time use.

After initial exploration in the introduction of the science unit, teachers gave students opportunities to explore the resource within teacher set parameters. Teachers determined when students had a suitable understanding of the topic and then gave students freedom to seek for answers to problems within a defined set of restrictions. Usually this involved limiting student exploration to certain zones of learning in the Zoology Zone multimedia resource or by limiting time students had to complete an assigned activity.

The capability of the multimedia resources to appeal to student curiosity by having students explore and investigate science categories of study had benefits in the science classroom. The capability of multimedia resources to make the less visible more visible encouraged learning and provided benefits to the science students that would not be possible in a classroom demonstration. For example, eight spider eyes were illustrated on a spider diagram and then identified with arrows and flashing highlights on a slide of a live spider. Some of the difficult concepts of science(e.g., life cycle of the butterfly) that students would traditionally have to 'imagine' could be clarified with animations, visualization and graphics that were possible in the multimedia resource.

The teachers pointed out limitations of multimedia resources in the science classroom. The most limiting factor was that multimedia resources did not provide the 'real life' experience for the students. Teachers said that they felt science must be hands on and involve experimentation and application to life experiences of the students. For this reason, the teachers indicated that multimedia resources in the science classroom should complement learning activities that are not computer based. Fieldwork, investigation in the classroom and community, and a sharing of student experiences with the phenomena being studied was viewed as important if students were to develop a comprehensive understanding of the science concepts to be developed.

The teachers stated that multimedia resources are best used in conjunction with other teaching resources. They felt that students must come to understand that technology can be used to augment other types of teaching resources and teaching activities. Students can extend their learning through a variety of learning resources that all contribute to development of meaning and understanding of science phenomena. The inclusion of complementary reference books, models, displays and other opportunities teachers provided for students in addition to the use of the CD-ROM illustrated the emphasis teachers put on student access to multiple resources. Books and other non-computer based learning resources can contribute to student learning and also contribute to a student appreciation of the role of technology as only one of many resources to facilitate student learning.

This Zoology Zone multimedia resource, due to motivational appeal and fit with science objectives, was useful to the teachers. Selection of resources and placement of them in the teaching plan is an important first step for the teacher in planning for instruction in both science and technology education. Multimedia resources can only be effective if they are appropriate to the learning objectives. Teachers have a critical role in determining the appropriateness of selected resources and deciding how to augment multimedia resources with other resources and learning activities.

The teachers were sensitive to the expectation that they address the objectives of the science curriculum and this emphasis posed a dilemma for them in determining a balance between direct teaching and student directed learning. Repeatedly, teachers discussed the importance of meeting the specific learner expectations which must be met as defined in the program of studies. This emphasis was reflected in the teacher directed components of the science unit in which teachers imposed restrictions on student exploration of the CD-ROM to ensure that students completed assigned learning activities and specifically addressed challenges initiated by the teacher. The imposed structure for learning to address issues of accountability interrupted the natural curiosity of the students that was evident in the free exploration phases of instruction. The teachers felt the pressure to complete assigned units of study early enough in the year to prepare students for the provincial achievement tests in Language Arts and Mathematics. Teachers knew students were enjoying learning in the unit but felt pressure to direct the learning to meet time constraints and ensure that students were achieving the goals of the curriculum. Clearly, teachers felt the pressure of the achievement tests in June and the need to have sufficient time to prepare students for the provincial achievement tests. Completing the science program for the year prior to the preparation for achievement exams was a concern of the four teachers in the study.

Criticisms of the Alberta Elementary Science Program of Studies became evident. The teachers stated their support for the principles of science inquiry, constructivist learning and 'big' ideas in science. However, these ideas are not clearly evident in the program of ssience studies. Teachers stated that they were not provided with sufficient direction to understand these approaches and to plan science instruction around them. It became evident that if knowledge acquisition is not the priority for elementary students' science learning, then adjustments need to be made to the science curriculum. This could be done by reducing the number of topics of study in each grade or by limiting the content SLEs for each topic. Teachers pointed out that it was unreasonable to complete all the expectations in the grade three science program in the time allotted for science

teaching. The amount of content to be taught in five topics of study was not compatible with the desire of teachers to carry out science inquiry and constructivist approaches to teaching.

Teacher Learning and Multimedia

Research Questions:

The research questions, which guided this dimension of the study, were:

1. What challenges do teachers discover in the use of the Zoology Zone multimedia resource in the teaching of the elementary science program?
2. How do teachers describe their learning experiences using the Zoology Zone multimedia resource in the teaching of the grade three animal life cycle science unit?

Teacher participants uncovered some of the drawbacks of multimedia resources and these limitations needed to be considered in the use of the Zoology Zone multimedia resource. It took time to set up multimedia resources and considerable effort on the part of the teacher to ensure the resource was available for student use. Testing and previewing the resource, scheduling access to computers, and determining appropriateness of the content to the learning expectations for the unit were time consuming. Teachers also found that multimedia was sometimes distracting to the learner in that staying on task was at times difficult due to appeal of games, animations or other special features of the resource. Having several computers displaying different screens of multimedia simultaneously was also distracting to students. Even when headphones were available, the visual distractions to some students resulted in some students losing the focus on their own learning. The quantity of information in the multimedia resource also contributed to overwhelming some learners who experienced information overload and had difficulty sorting through the resource and applying the information to their learning of concepts. Temptations existed for some students to explore freely and not stick with a learning activity to completion.

The teachers found that they were also challenged by the multimedia itself and they were often co-learners with their students. The teacher became a member of the learning team providing technical assistance and creative consultation, rather than simply directing students to complete narrowly defined tasks. The teachers shared experiences in which they were co-learners with the students. This was evident when the students discovered various components of the multimedia that the teacher had not uncovered (e.g., animation features, technical shortcuts).

Unlike other more traditional teaching resources, multimedia resources provided many opportunities for the teacher to act as a tutor, guide and facilitator which required a shift in how some of the teachers approached teaching. When students used the multimedia resource, the teacher was not the main focus in the classroom. The engagement of students with the multimedia resource diverted attention from the teacher to the student interaction with the resource. Teachers needed to determine a balance between teacher directed and student directed learning.

The teacher participants felt that their role in assessment must address the individual learning of each student and that individual assessment was not effectively done in standardized test formats. Although some testing was done, the teachers did not rely solely on tests to assess student learning in the Animal Life Cycle topic. Rather, they used a variety of data in assessing student understanding of the unit concepts including journals, research projects, assignments, and individual and class discussions. These assessment strategies were facilitated by teachers in the role of facilitator or guide which allowed for one to one interactions with each student.

The teachers discovered the importance of the development of coping strategies for using multimedia resources. Preparation for technical failure should be part of any lesson plan using multimedia. Back up plans were important because, when teachers encountered technical difficulty, other teaching plans needed to be readily accessible. All four teachers experienced some technical problems in the progress of the unit (e.g., video projector not

working) and found that they had to proceed with alternative plans from their intended lesson plans.

The teachers indicated that they learned about multimedia resources and science teaching as the research study progressed. Like their students, the teachers constructed meaning based on new information and by building on previous experiences. When the teachers had access to 'just in time' learning with multimedia resources and were given opportunity to apply that learning they increased their understanding of multimedia resources. The importance of trying the multimedia resources, freely exploring it and building on that experience increased teacher confidence with use of the resource as an instructional tool. Further to this, the teachers found that if they could meet with other teachers and share learning about the multimedia resource, they learned more about effective use of multimedia and were able to create learning environments in their classrooms that facilitated student learning with multimedia resource. In this study, the teachers discussed satisfaction with the opportunity to share strategies for multimedia resource use in their classrooms and indicated that they grew both in their understanding of multimedia and the implications for effective use in the science classroom. Their learning came from their discussions in which they shared their experiences with other teachers using the same teaching resource.

It was evident from the study that the teacher participants experienced professional growth in the stages of technology integration as defined by Hooper and Rieber (1995). At the onset of the study the teachers were at the integration phase (Heather, Roberta, and Leslie) and the reorientation phase (Suzanne). Support from the others in the study and support from the researcher assisted the teachers in gaining a deepened understanding of multimedia resources and possibilities for integration of it in teaching. In regards to professional development of teachers, the stages of integration provide benchmarks for determining appropriate professional development activities for each teacher.

Teaching is a complex endeavour that can be positively influenced by experience and knowledge. Multimedia technology, relatively new as a tool for learning in elementary classrooms, presents many challenges that teachers must

explore in determining appropriate use of multimedia resources in the classroom setting. For purposes of determining professional development activities for teachers, it is important to address the entry level understanding of the teacher and to account for differences in teaching experiences.

Researcher Views on Teacher Learning

As the researcher, I observed teachers growing and learning as the project progressed. In addition to information shared by the teachers identifying what they had learned in the research study, I witnessed growth in areas in which they did not volunteer contributions. For Heather, it became clear that her confidence with multimedia resources increased substantially as the project progressed. I noted an increase in her ability to integrate the multimedia classes with her other learning activities in science and other subjects as I visited her classes. Leslie demonstrated an increase in her confidence as well and made changes to her instruction plans as she observed the impact of the multimedia resources on her classes (e.g., changed to pairing students for the bear unit). For Roberta, the flexibility in managing her limited resources resulted in some new arrangements for teaching (e.g., splitting her class in half, use of journals) that worked well for her. The others in the group utilized her ideas. All four teachers developed a familiarity with the language of multimedia and an appreciation for the potential of multimedia resources to enhance student learning. They also discovered that there are limitations with multimedia resources and that the teacher was a critical factor in designing student learning opportunities that respect both the limitations and strengths of multimedia resources in the elementary science classroom.

As an outcome of participation in the study, teachers learned in many ways. They learned about multimedia technology by being put in a situation where they were obliged to use the Zoology Zone multimedia resource as a significant resource in the Animal Life Cycle science topic of study. They learned from their own experiences in their classrooms. They learned from their students. They learned from the other participants. The participants were co-

learners in the research study. As they wrestled with how to teach using the Zoology Zone multimedia resource, they encountered challenges that they addressed. These challenges and the subsequent strategies to deal with the challenges resulted in learning by all the participants in the study. By the end of the study, each teacher had added knowledge, skills, and understanding to their repertoire of effective teaching skills.

Reflections of the Researcher

As the researcher I learned a great deal during the process of carrying out the research study. When the study was completed, I reflected on my personal learning in the process and drew several conclusions about my work with the four teacher participants. I appreciated that teachers spoke freely about their experiences and that they were frank in sharing their experiences. Initially, I had thought that some participants might be intimidated by the input of others but that did not happen. In fact, each teacher was quite confident in challenging other teachers about their approaches and interpretations. I was concerned that I might dominate the group discussions given that I had information about the experiences in all four classrooms and was well informed about the Zoology Zone multimedia resource. I implemented various strategies to compensate for this situation which I thought might discourage meaningful sharing of experiences between participants. Reflection sheets, a pre determined order of sharing and use of my research assistant as a coach were strategies I employed to keep dialogue focussed for the participants. However, these approaches were not really necessary.

My perceptions of multimedia resource use in the elementary science classroom changed significantly during the progress of the study. At the onset of the study, I was of the opinion that multimedia resources had a strong place in the elementary classroom. I felt computer technology, in general, had a strong place if used appropriately. Now, I am much more cautious in my promotion of technology in the teaching of primary school children. Educating primary students on basic literacy and numeracy are high priority teaching mandates

because these basic skills provide a critical foundation for subsequent learning in school. Use of computer technology should not detract or interfere with the teaching of basic numeracy and literacy. Technology, and multimedia in particular, has a place in student learning but the role of the teacher is critical in providing parameters for technology use and determining when and how computer technology can enhance the teaching of basic skills. In light of constructivist learning theory and the educational needs of young learners, I recommend that educators critically review the use of computer technology and proceed cautiously when using it in the teaching of young children.

CHAPTER SEVEN
IMPLICATIONS

Introduction

The experiences of the four teacher participants in this study point to some recommendations for teacher professionals, administrators and developers of educational policy and practice.

Teachers in Elementary Schools

Multimedia Potential

Teachers are encouraged to be aware of the availability and the potential of multimedia to enhance student learning in science and to explore ways to implement multimedia as one effective learning resource in classrooms. Multimedia resources can have strong motivational appeal to children, can engage children in technology-based learning, and can provide opportunity for teachers to personalize learning for all students in the classroom.

Teachers need to exercise professional responsibility to situate multimedia teaching resources appropriately in the teaching plan. Selection of teaching approaches that best assist students to learn is part of that plan. It is critical to select developmentally appropriate multimedia resources and to develop supportive learning activities that are effective for young students.

Teachers are encouraged to explore ways to address multimedia technology as part of the teaching of subject curricula. Objectives from both the ICT outcomes and the science curriculum can be achieved concurrently if teachers plan carefully.

Planning for Instruction

Multimedia resources need to be critically previewed by teachers to ensure that content is compatible with Alberta programs of study. Teachers should be attentive to use of multimedia resources to meet the specific learner expectations that are outlined by educational policy makers. Teaching strategies must be selected that assist student learners in using multimedia resources to

achieve the broader objectives of the science curriculum which focus on understanding. To this end, teachers may need to provide direction so that students make the best use of multimedia resources in science learning. Teachers should develop an understanding of all dimensions of a program of studies and not focus instruction on knowledge objectives to the exclusion of other important dimensions of learning such as the skills of science inquiry and development of positive attitudes about science.

Standards for Professional Practice

Teachers are encouraged to influence the setting of standards for professional practice that free students to control their learning and to become familiar with how they learn. By educating students about the benefits of being aware of how they learn, teachers can positively influence student learning and encourage lifelong learning skills in science as well as other areas of study. Teachers are encouraged to have the courage to adopt constructivist teaching approaches in their science classrooms and to implement performance assessment strategies that recognize the different entry level points students bring to the science classroom. Many options exist for students to pursue legitimate learning pathways in the acquisition of new learning.

School Administration in Elementary Schools

Professional Development

Teachers need to be given opportunities for professional development that allow them to learn about constructivist teaching and effective uses of multimedia resources. When administrators encourage the development of peer coaching teams, and provide opportunities available to teachers to work together on development of programs and teaching strategies they are taking positive steps in encouraging positive changes in teaching. It may be useful to have professional development that provides teachers with strategies to understand the depth and breadth of programs of study and to learn pedagogy that is

compatible with all the dimensions of learning outlined in mandated programs of study.

Teacher Support

School based administration can be very helpful in encouraging effective practices in both science education and the use of multimedia technology. Administrators are encouraged to affirm teachers in the implementation of constructivist teaching in science instruction and in technology integration. Administrators can also be instrumental in providing necessary technical support and access to facilities and resources that encourage teachers to use multimedia resources and adopt constructivist teaching approaches. Administrators need to be attentive to the amount of time that is required for teachers to utilize multimedia and to effectively implement constructivist teaching. Both teaching approaches require focussed time and energy of the teacher and given the constraints of many school programs of study adjustments to schedules and expectations of teachers may be necessary. Adequate support for teachers in allocation of time, required basic resources, equipment and support personnel are essential in both science and technology teaching. Use of multimedia is time intensive, in part, due to the dependency classroom teachers must have on other personnel in a school. Using school based hardware and software is not an isolated activity and involves communication, planning and co-operation with other personnel in a school.

Student Assessment

Administrators need to review systems of assessment and critically evaluate the role of standardized testing and its effect on teaching primary students. Consideration given to non-standardized student assessment strategies that are compatible with constructivist theories of learning (i.e., portfolio assessment) may be beneficial to student learning. When standardized tests are mandated, administrators can play an important role in the determining the emphasis, significance and interpretation that is attached to the results. Furthermore, administrators have a role in supporting teachers in assessment

strategies that differ from standardized approaches but that may encourage student learning.

Developers of Educational Policy and Practice

Student Assessment

Educational policy makers need to continue the dialogue between all stakeholders in education (e.g., parents, teachers, school boards, provincial governments) about compatibility between assessment practices and instructional practices. Student learning is the mission of schools and educators need to respect what is known about how students learn. There must be a balance between standardized testing and other forms of student assessment if teachers are to provide the best learning environments for students. Educators as advocates for elementary school aged children may need vision, courage and support to champion instructional practices that focus on the student directed learning. These may include increased support for assessment strategies that are compatible with constructivist learning and may also involve decreasing the emphasis on standardized tests, which often focus on testing knowledge. Too much emphasis and demand on teachers to provide student grades (i.e., A, B, C) can discourage constructivist approaches to teaching.

Multimedia Resource Development

Educational policy makers need to promote the development of multimedia resources that address the mandates set out in programs of study and are appropriate to the reading levels of students and the learning objectives in a program of study. Ensure that the resources are available and affordable to schools and supports are in place to assist teachers in accessing and implementing the multimedia resources in classrooms.

Technology Outcomes

Educational policy makers need to encourage schools to use multimedia technology to promote student learning in information and communication

technologies. Guidelines for technology integration in elementary schools must be specific and reasonable. Teachers can benefit from specific directions on the use of technology in each program of study rather than having to take the responsibility to determine where and how technology may be utilized in the all programs of study. Increasingly, these directions are being included in newly released curriculum documents in Alberta. Furthermore, expectations for technology use cannot be so rigorous that the focus on learning basic skills (e.g., literacy and numeracy) is averted. Technology has a significant place in schools but young learners require many other skills prior to being able to effectively develop technology skills and this should be reflected in the provincial mandates to elementary schools on matters of technology use.

Chapter Summary

The potential of multimedia technology as a teaching resource needs to be considered in classroom instruction. Reform in education could enhance student learning if more attention is given to implementation of educational practices that honour how students learn, appreciate and recognize the value of multimedia resources and respect how teachers learn.

One outcome of this research study has been my personal experience of professional growth. I have developed new perspectives on elementary teaching and how the mandated curriculum influences teaching. New questions have surfaced for me pointing to the need to critically evaluate curriculum in light of educational theory about how students learn and how teachers learn. I believe that most teachers are committed to being the best teachers they can be. This can be facilitated by support from all educational stakeholders by ensuring that the curriculum in place is relevant, and that adequate support is in place to provide teachers with a thorough understanding of the breadth and depth of the curriculum. If all stakeholders in education further applied what is known about technology, student and teacher learning, the impact on improvements in student learning could be more significant.

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APPENDIX A

Zoology Zone – Student Learning Activities

Learning Zone	Learning Activities
All About Me	Legend of Arachne
	Scary or Nice?
	Insect or Spider?
	Parts of the Body
	ArachnaRap
	Spider Puzzle
How I Grow	Spider Reproduction
	Spider Diary
	Life Cycles
	Life Cycles Game
	Parental Care
Where I Live	Spider Homes
	Habitat Riddle
	Spider Enemies
How I Eat	What I Eat
	Trapping
	Build a Web
	Hunting
Did You Know?	All About Me
	How I Grow
	Where I Live
	How I Eat
	Other Facts

APPENDIX B

Grade Three Topic E: Animal Life Cycles

Overview

Students learn about the growth and development of animals and discover that different animals have different life cycles. By observing the life cycle of one small animal from its earliest stage to adulthood, students acquire a reference point for the study of other animals and come to appreciate the beauty and fragility of life. Students learn that the *egg, larva, pupa* and *adult* stages that are characteristic of many insects represent a different life story from that of the *egg, young, adult* life cycle that is common to most vertebrate animals. In studying these animals, students learn about the changes in needs of the young as they grow and develop and about the changing relationship between these animals and their environment.

General Learner Expectations

Students will:

3–10 Describe the appearances and life cycles of some common animals, and identify their adaptations to different environments.

3–11 Identify requirements for animal care.

UNDERSTANDINGS

Specific Learner Expectations

Students will:

1. Classify a variety of animals, based on observable characteristics; e.g., limbs, teeth, body covering, overall shape, backbone.
2. Observe and describe the growth and development of at least one living animal, as the animal develops from early to more advanced stages. The animal(s) should be from one or more of the following groups: mammals, birds, fish, reptiles, amphibians, insects. Suggested examples include: gerbils, guppies, mealworms, tadpoles, worms, butterflies/moths. Additional examples from other animal groups might also be included: brine shrimp, isopods, spiders.
3. Predict the next stages in the growth and development of at least one animal from each of the following groups: mammals, birds, fish, reptiles, amphibians, insects; and identify similarities and differences in their developmental sequences.
4. Identify the food needs of at least one animal from each of the following groups: mammals, birds, fish, reptiles, amphibians, insects; and describe changes in how each animal obtains food through different stages of its life.

5. Demonstrate awareness that parental care is characteristic of some animals and not of others, and identify examples of different forms of parental care.
6. Demonstrate awareness that animals require different habitats in order to meet their basic needs of food, water, shelter and space.
7. Recognize adaptations of a young animal to its environment, and identify changes in its relationship to its environment as it goes through life; e.g., tadpoles are adapted for life in an aquatic environment; adult frogs show adaptations to both terrestrial and aquatic environments.
8. Identify examples of environmental conditions that may threaten animal survival, and identify examples of extinct animals.
9. Recognize that habitat preservation can help maintain animal populations, and identify ways that student actions can assist habitat preservation.
10. Demonstrate knowledge of the needs of animals studied, and demonstrate skills for their care.

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APPENDIX C

ICT Outcomes: Division 1

C.1 - Students will access, use and communicate information from a variety of technologies.

C.2 - Students will seek alternative viewpoints, using information technologies.

C.3 - Students will critically assess information accessed through the use of a variety of technologies.

C.4 - Students will use organizational processes and tools to manage inquiry.

C.5 - Students will use technology to aid collaboration during inquiry.

C.6 - Students will use technology to investigate and/or solve problems.

C.7 - Students will use electronic research techniques to construct personal knowledge and meaning.

F.1 - Students will demonstrate an understanding of the nature of technology.

F.2 - Students will understand the role of technology as it applies to self, work and society.

F.3 - Students will demonstrate a moral and ethical approach to the use of technology.

F.4 - Students will become discerning consumers of mass media and electronic information.

F.5 - Students will practise the concepts of ergonomics and safety when using technology.

F.6 - Students will demonstrate a basic understanding of the operating skills required in a variety of technologies.

P.1 - Students will compose, revise and edit text.

P.2 - Students will organize and manipulate data.

P.3 - Students will communicate through multimedia.

P.4 - Students will integrate various applications.

P.5 - Students will navigate and create hyperlinked resources.

P.6 - Students will use communication technology to interact with others.

Source: Information and Communication Technology (K-12) (2000-2003).

http://www.learning.gov.ab.ca/ict/outcomes/div1.asp

Contact: doug.knight@gov.ab.ca

APPENDIX D

Lynne D. Paradis
29 Dandell Close
Red Deer, AB
T4R 2J3

June 1, 2000

Dear Grade Three Teacher:

You have been invited (invitation attached) to the launching of the Zoology Zone multimedia teaching resource because the resource has specific relevance to grade three students. The Zoology Zone resource is a set of three CD-ROMS. Each CD-ROM presents a study of one group of animals. The three animal groups studied are Spiders, Bears and Raptors. If you will be teaching grade three science in September 2000, an opportunity exists that I ask you to consider.

I have been involved in the development of the Zoology Zone teaching resource and am using these resources to carry out a study as part of my doctoral work at the University of Alberta. I am seeking a small group of grade three science teachers (likely four in total) who would agree to do Topic E: Animal Life Cycles as the first unit of science study in September. These teachers would be given all the necessary software to teach the unit to a class of grade three students. As part of the research project I want to talk with teachers about their experiences in working with multimedia resources in the classroom. The project involves a total of six after school meetings (possibly supper meetings pending interest of the group) in which the group of teachers meets together with me and discusses teacher experiences with the Zoology Zone resource. Teachers in the research project must have access to computers with CD-ROM players in their schools (PC or Mac). I am looking for a variety of teachers with varying experience in both science and technology implementation. Attached is a brief participant survey to be completed by you if you are interested in being part of the research group. The survey assists me in identifying participants with varied teaching approaches and experience.

If you think you may be interested in this opportunity please be my guest at the official launching of the resource and bring the participant survey with you. If you cannot attend the launching but are interested in being a participant in the project contact me (phone 342-4800 work, 343-8512 home, email lparadis@rdcrd.ab.ca) and I will provide follow up information and make arrangements to pick up the participant survey. There will be generous opportunity to view the resource at the launching and to talk to other teachers and students who used the resource in the field-testing. All teacher participants in the research project will receive complimentary Zoology Zone software for their personal collections of teaching resources. I hope to see you at the launching and hope you consider involvement in my research study. Your superintendent is aware of this project and has given support to proceed in your school district with the research project. Please contact me if you have any questions.

Sincerely yours,

Lynne D. Paradis

APPENDIX E

Participant Survey

Zoology Zone Multimedia Research Project

June 2000

The purpose of this survey is to get some background information from teachers considering participation in the Zoology Zone research project. Please fill out the survey and return to researcher Lynne Paradis (drop off at Notre Dame High School, bring to the official launching of the project (June 21), or phone 343-8512 (home) or 342 4800 (work) to make arrangements for pick up)

Teacher Name:_____

School:_____

Years of completed teaching experience:_____

Phone number:_____(school)_____(home)

Circle the response responses that most closely describe you or your teaching style.

1. My formal education in science is best described as:

    a. No formal university science coursework
    b. Mandatory courses that I had to take to get my degree(s)
    c. Some focus on science interest—five or fewer university science courses
    d. Major focus on science -- more than five science courses
    e. Professional development in science education following university training

2. My feelings about teaching elementary science are best described by:

    a. I dislike science and teach it because it is mandatory
    b. Science is one of my less favourite subjects to teach and I would happily trade it with another teacher

c. I am indifferent to science and don't have strong feelings one way or another
d. Science is one of my favoured subjects –I am often thinking about things to do with my students in science class

3. My feelings about technology integration in my classroom are best described as:

a. I do some technology integration largely because it is the expectation in my school to do so.
b. I am consistently thinking about new ways to use technology with my students and try new things with technology.
c. I have my students use technology regularly in humanities subjects (Language Arts and Social Studies)
d. I regularly have students use technology in Math and Science.
e. Technology use is ongoing on a daily basis in my classroom and used by all students in a variety of ways.
f. I find it challenging to use technology in an effective manner in the classroom setting given the nature of technology in my school.

4. Circle the descriptors that best describe the classroom climate in your grade 3 science class:

a. Direct teaching most of the time
b. Co-operative learning groups
c. Highly organized and structured planning
d. Student input used in determining ideas to be studied
e. Students work quietly and independently
f. Desks arranged in rows
g. Desks arranged in pods
h. Desks arranged in alternatives to rows and pods
i. Productive noise of students(noisy class but working)
j. Students choose whether to work in partners, groups or independently
k. Independent program plans for many of the students

5. When planning for a science unit what best describes you?

a. I stick to the daily plans most of the time.
b. I am flexible and often vary from the plans when student activity indicates interest in an alternative plan

6. In regards to assessment of student progress in science check off the descriptors that best describes your system of science assessment

a. Peer assessments
b. Self assessments
c. Quizzes, unit tests
d. Research projects, presentations and labs
e. Participation

Other:

Thank you!

APPENDIX F

Letter of Invitation to Participants

June 30, 2000.

29 Dandell Close
Red Deer, AB
T4R 2J3

Dear (participant name),

I am a doctoral student at the University of Alberta am inviting you to participate in my research. I am researching teacher experiences with multimedia in elementary science classrooms. I will provide an overview of my research project at an orientation interview at the beginning of the study. At this time I will provide you with a CD-ROM package of multimedia materials called Zoology Zone. You will be asked to implement the multimedia resource as part of an elementary science unit. At intervals during implementation of the resource, I would like to interview you about your experiences in the classroom. Following the individual interview you will be invited to share your experiences with other teacher participants, in a group discussion. The purpose of the individual interviews is for me to gain an understanding of your experiences with the resource and possibly assist me in my role as facilitator during the group interviews. The purpose of the group interviews is to have all teacher participants (four in total) share experiences and possibly gain new understanding about the resource and use in science classrooms.

The interviews will be semi-structured. This means that teachers will be encouraged to contribute their experiences in as comfortable a discussion setting as possible. As facilitator, I will provide guiding questions to move the conversation along and to address various categories that emerge during the individual interviews. The interviews will be audio-taped and a transcript and summary of each interview will be developed to assist me in understanding experiences discussed in interviews. You will have opportunity to review and amend all transcripts of interviews with you, drafts of the thesis and audio-tapes prior to publication. After publication of the study, all audio-tapes will be erased. My advisor and I will be the only people who have access to the transcripts and tapes of the individual interviews. The transcripts, audio tapes and summary notes from the group interviews will be available to all four teacher participants. Your name or position will not be identified nor be released to anyone. You have the right to withdraw from the research at any time without penalty. The end result of this research project will be the publication of my dissertation. You will be notified when the dissertation is published.

I appreciate your consideration to be a participant in this study. If you choose to participate in the study please complete the attached consent form and return to me. Should you choose to participate I will contact your school principal and request that a consent form be completed acknowledging support for your participation in the project (see attached). If you have any questions or concerns about the study or the interview process, please contact me at (403) 343-8512 or by email at lparadis@rdcrd.ab.ca.

Sincerely yours,
Lynne D. Paradis

APPENDIX G

Teacher Participant Consent Form

Name: _____

Telephone: _____

Email: _____

Address:

_____

_____

I, _____, DO consent to participate in Lynne Paradis's research project on teacher experiences with multimedia in elementary science classrooms.

_____ _____

Signature **Date**

For further information concerning the completion of this form, or the research study, contact Lynne Paradis at (403) 343-8512, or email at lparadis@rdcrd.ab.ca.

APPENDIX H

July 10, 2000
29 Dandell Close
Red Deer, AB
T4R 2J3

Dear (Supt. name),

I am inviting your school district to participate in my research. I am a doctoral student at the University of Alberta researching teacher experiences with multimedia in elementary science classrooms. I am seeking four grade three science teachers to participate in a study in which they utilize a multimedia science resource, called Zoology Zone, in the teaching of one unit in the grade three science program.

I will provide an overview of my research project at an orientation interview at the beginning of the study. At this time I will provide teachers with a CD-ROM package of multimedia materials called Zoology Zone. Teachers will be asked to implement the multimedia resource as part of an elementary science unit. At intervals during implementation of the resource, I would like to interview teacher participants about their experiences in the classroom. I would also like to visit each teacher's classroom at least once to gain an understanding of the environment in which the Zoology Zone resources are being utilized. Following individual interviews teacher participants will be invited to share experiences with other teacher participants, in a group discussion. The purpose of the individual interviews is for me to gain an understanding of teacher experiences with the resource and possibly assist me in my role as facilitator during the group interviews. The purpose of the group interviews to have all teacher participants (four in total) share experiences and possibly gain new understanding about the resource and use in science classrooms.

I am requesting permission to approach grade three teachers in your school district to be part of this study. Teachers interested in participating in the project will be asked to teach the Animal Life Cycles unit in the grade three science program as the first unit of study beginning September 2000. A copy of the findings in the study will be available to all school districts participating in the study. If you have any questions about the study, please contact me at (403) 342 3800 (w), 343 8512 (h) or contact my research advisor, Dr. Dianne Oberg at (780) 4924273.

Sincerely yours,
Lynne D. Paradis

APPENDIX I

Zoology Zone Research Project
Initial Meeting with Participants
August 24, 2000.

1. Welcome and introductions
   a. Individuals give background of teaching and interest in the project
   b. Status of the project
   a. Selection of participants (invitation, Zoo Zone launching, questionnaire completion)
   b. Conditions of involvement
      -teaching grade 3 science
      -first unit Animal Life Cycles
      -availability to CD players
      -commit to individual interviews and group interviews, feedback on the implementation of multimedia materials
      -openness

2. Overview of the Research Project
   a. Review of project proposal
   b. Role of Participants
      -information gathering options
      -confidentiality of students
      -sharing of experiences
      -PD component of the project
   c. Role of Researcher
      -collecting data
      -taping interviews
      -provision of transcripts of interviews
   d. Role of Research Assistant

3. Procedures
   a. School classroom visits
   b. Individual interviews
   c. Group interviews
   d. Other data collection instruments (lesson plans, reflections, journals, etc.)

4. Administrivia
   a. Completion of consent forms for participation
   b. Consent forms for school principals
   c. Approval of Supt of Schools for participation in the project
   d. Dates for implementation
   e. Email and contact list (best times to contact each other)

5. Zoology Zone Resource
   a. Distribtion of copies of CD-ROM and teacher guide
   b. Documents for project: Teacher guide, CD-ROM, Science Program of studies, Technology Outcomes document.

6. Discussion and questions regarding project involvement

7. Calendar
   a. Meeting dates.

APPENDIX J

Individual Interviews: Question Guide

These questions were used in the first and/or second individual interviews with teacher participants.

- Tell me about your teaching background and teaching experience.
- What are your views on technology integration in grade three?
- How have you used technology in your classroom?
- What is your understanding of multimedia as a teaching resource?
- What are your views on science teaching at grade three?
- What is it like to be a student in your classroom? How do you manage your class? How do you plan for instruction?
- How did you prepare for the first lesson using the Zoology Zone multimedia resource?
- What were the student reactions to the resource?
- Were there any challenges you faced in the initial implementation of the resource?
- How did the resource influence student learning in science?
- Can you identify any benefits of using the resource in the science unit of study?
- What happened in the classroom when you used the multimedia?
- Can you account for why students reacted in a certain way?
- Describe your role as teacher when students used the resource?
- Can you identify any limitations to using multimedia in science teaching?
- What do you identify as useful in the implementation of the resource in your science classroom?
- Would you do anything differently the next lesson you use the multimedia resource?

All teachers were asked the following question during the second individual interview:

- What advice would you give to a student teacher if they were given the Zoology Zone multimedia resource and invited to use it in the teaching of the animal life cycle unit?

APPENDIX K

ZOOLOGY ZONE PROJECT
GROUP MEETING NUMBER TWO
SEPTEMBER 26, 2000.

1. Welcome and refreshments
    a. Updates: List serve, individual interviews and transcripts, CD cases and copies

2. Personal reflection and feedback sheets

3. Group sharing:
    a. order of sharing
    b. guidelines for sharing (all ideas have value, no correct approaches, opportunity for new ideas and growth)
    c. role of research assistant and audio-tape recorder

4. Next steps.
    a. class schedules
    b. visits to classroom
    c. individual interviews
    d. group meeting #3
    e. review of calendar and balance of project

APPENDIX L

Zoology Zone Project

Group Meeting #3

October 10, 2000.

3:34 p.m.

1. Welcome, refreshments, and updates

    a. Status of spider completion
    b. Distribution of Bear CD
    c. Support references: Teacher guide, ICT outcomes, Program of Studies
    d. Internet sites status (e.g., Optional sites available: not monitored)

2. Personal reflection and feedback

    a. Reflect on unit implementation of Spider and jot down input based on your classroom experiences.

3. Group sharing

    a. Roberta, Leslie, Heather, Suzanne

4. Next steps.....

    a. Classroom visits
    b. Individual interview #2 by appointment
    c. Subsequent classroom visits
    d. Collection of support documents
    e. Tape transcripts
    f. Date for group meeting following Bear

APPENDIX M

Zoology Zone Project

Reflection and Sharing of Experiences

Planning – What did you do to ready for the lessons with Zoology Zone?

Implementation – What happened when you implemented the lesson(s)?

-what did the students do?
-what did you do ?
-anything unexpected?

Insights, reflections, interesting points to note.....

APPENDIX N

Group Meeting Number Four

Wednesday, November 15, 2000.

1. Introduction and updates

    a. Status of implementation (and use of Raptors)
    b. Value of contributions
    c. Purpose of today: Individual and group story, fill "gaps" in data , synthesize information from research project
    d. Timelines for today
    e. Research Journey: a chronological view and a review of the project objectives

2. Individual Stories

    a. The beginning of the project: "Why I got involved and what I came to the project with...

    b. Very brief overview of contributions during the implementation of Zoology Zone
        -things I tired.....
        -things I learned.....

3. Group story

    a. Emergent categories
    b. Other considerations beyond central categories
    c. Future applications, recommendations (things I could pass on to others?)

4. Next steps

    a. Sign off of transcripts
    b. Personal feedback on participation in the project
    c. Filling data gaps: feedback from participants on beliefs on how teachers learn and other emergent items from data collected
    d. Forwarding of additional classroom support information
    e. Return of project CD's and awarding of complimentary copies and commendation letters

APPENDIX O

Findings: Organized into Categories

I. Teacher Planning and Multimedia

   a. Unit development
   b. Technical considerations

II. Student learning and multimedia

   a. Freedom to explore
   b. Teacher directed learning
   c. Social dimensions of learning
   d. Student directed learning
   e. Learning distracters

III. Role of the Teacher

   a. Classroom management
   b. Curriculum expectations (Science and ICT)
   c. Student assessment
   d. Adapting teaching style

IV. Teacher Learning

   a. Teacher views on teacher learning

V. Puzzles in the data

APPENDIX P

Research Timelines

April 2000	Final revisions to Bear and Spider Zoology Zone resource
April 17 – 21	Approach two city school boards, one county school board administrations for possible participation in research.
	Positive responses, by telephone from three school districts.
April 24 – 28	Zoology Zone partners agree to media launching ceremony to be held before end of school term.
	Submission of Zoology Zone multimedia resource to Alberta Learning for approval as science resource.
May 1 – 5	Researcher volunteers to chair committee for resource launching. Committee formed and tasks assigned.
May 29 – June 2	One school district approves involvement in the project and assigns two 'helping teachers' to work with research on promoting teacher involvement in the research project.
	Researcher meets with helping teachers, shares resource and research project plans.
	One district declines offer to participate in project.
June 1	Invitations for launching sent to school districts, multimedia companies, Alberta Learning officials and other potentially interested individuals and organizations.
June 5 – 9	Publicize launching and encourage grade three teachers to consider participation in research project. Letters of invitation to participate in research project sent to all grade three teachers in the city. Participant survey forwarded to teachers interested in participating.

June 15	Completion of writing of draft of teacher guide for the Zoology Zone resource.
June 12 – 16	Preliminary approval by Alberta Learning of Zoology Zone as a science teaching/learning resource.
June 21	Official launching of Zoology Zone resource. List of teachers interested in participation in research project compiled.
June 26	Researcher reviews list of interested participants and assesses participant surveys.
June 27	Four grade three teachers identified and invited by researcher to be research participants.
June 28	Four teachers accepted (by telephone) the invitation to participate.
July 4 – 7	Telephone participants to confirm intent to participate and arrange to pick up consent forms, deliver letter detailing date of first group meeting and deliver additional sample copies of the Zoology Zone CD-ROMs.
July 10	Meeting with Suzanne Letter to superintendent requesting letter of permission to carry out research project in four city schools.
July 17	Letter of permission from superintendent received.
July 18	Meet with Heather (received consent form)
August 15	Approach Sally to consider research assistant invitation.
August 17	Confirmation by Sally to volunteer as research assistant.
August 24	First group meeting. All outstanding consents to participate received, project overview and calendar set for September.
September 2	Purchase of storage cases for class sets of CD-ROM's.
September 4	Delivered class sets of Spider CD-ROM to homes of each research participant (also teacher guides).
September 12	Interview, after school, with Roberta (audio-taped).

September 14	After school interview with Suzanne (audio-taped).
September 15	After school interview with Heather (audio-taped).
September 15	Morning interview with Leslie audio-taped).
September 16	Group interview number two.
September 27	Visit to Roberta's classroom.
September 28	Visit to Leslie's classroom.
September 28	Follow up support with multimedia company to assist teachers experiencing technical difficulty with software.
October 3	Visit to Heather's classroom.
October 10	Group interview number 3.
October 14	Technology: Power Up Conference (Central Alberta Regional Consortium). Participant in keynote speaker, David Jonassen's, sessions on technology and elementary education.
October 17	Interview with Leslie (audio-taped).
October 24	Visit to Suzanne's classroom.
October 27	Interview with Suzanne (at school and not audio-taped).
November 5	Telephone updates on progress with all four participants.
November 6	Interview with Leslie (after school and not audio-taped).
November 7	Interview with Roberta (at coffee shop and not audio-taped)
November 8	Interview with Heather (at school and not audio-taped).
November 15	Group interview number four.
November 20 – 30	Meet with individual participants and review changes to transcripts of meetings.
Nov. – January 10	Writing of first draft of research findings.

January 11, 12	Meet with each teacher participant and research assistant to give draft one of chapters 4,5 and 6 and seek their input on the content of the chapters.
January 13 – 15	Speak with participants in the study and make changes to first draft according to recommendations.
January 19 – 31	Visit each participating school and make a presentation to the school of Zoology Zone teaching materials.
March 1 – 5	Individual interviews with each participant.